Epidemiological Study of Prevalence of *Cysticercus cellulosae* in Pigs of Jammu Region

BY

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Thesis submitted to faculty of Postgraduate Studies
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Division of Veterinary Public Health and Epidemiology
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CERTIFICATE-I

This is to certify that the thesis entitled **"Epidemiological Study of Prevalence of *Cysticercus cellulosae* in Pigs of Jammu Region"** submitted in partial fulfillment of the requirement for the degree of **Master of Veterinary Sciences** in **Veterinary Public Health and Epidemiology** to the faculty of Post-Graduate Studies, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu is record of bonafide research, carried out by **Miss. Rashmi Sharma,** Registration No. **J-15-MV-429** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

It is further certified that help or assistance received during the course of investigations have been duly acknowledged.

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Place: R.S. Pura, Jammu
Date: 26-07-2017

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CERTIFICATE-II

We, the members of the Advisory Committee of **Miss. Rashmi Sharma,** Registration No. **J-15-MV-429,** a candidate for the degree of **Master of Veterinary Sciences in Veterinary Public Health and Epidemiology,** have gone through the manuscript of the thesis entitled **"Epidemiological Study of Prevalence of *Cysticercus cellulosae* in Pigs of Jammu Region"** and recommended that it may be submitted by the student in partial fulfillment of the requirements for the degree.

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ABBREVIATIONS

%	**Percent**
@	**At the rate**
<	**Less than**
=	**Equal to**
>	**Greater than**
&	**And**
µm	**Micrometer**
cm	**Centimeter**
mt	**Meter**
E. granulosus	***Echinococcus granulosus***
T. solium	***Taenia solium***
T. saginata	***Taenia saginata***
T. asiactica	***Taenia asiatica***
et al	**Et alia**
etc.	**Et cetera**
Figs.	**Figures**
Gm	**Gram**
Spp.	**Species**
HIV	**Human Acquired Immunodeficiency Syndrome**

SCID	**Severe Combined Immunodeficiency Syndrome**
CIEP	**Counter Current Immune Electrophoresis**
ELISA	**Enzyme Linked Immuno-sorbent Assay**
Ag ELISA	**Antigen Enzyme Linked Immuno-sorbent Assay**
HP10	**Human and Pig 10 antigen**
Ab	**Anitbody**
EITB	**Enzyme Immunotransfer Blot**
Ts antigen	**Testosterone antigen**
USG	**Ultrasonography**
OR	**Odds ratio**
RR	**Relative Risk**
P	**Probability**
CI	**Confidence Interval**
Aq.	**Aqueous**
WHO	**World Health Organization**
GOI	**Government of India**
FAO	**Food and Agricultural Organization**
OIE	**Office International des Epizootics**
NCC	**Neurocysticercosis**

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"IN THE NAME OF GOD, THE MOST GRACIUOS, THE MOST BENOVALENT AND THE MOST MERCIFUL"

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ABSTRACT

Title of the Thesis	:	Epidemiological study of Prevalence of *Cysticercus cellulosae* in Pigs of Jammu Region.
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The present study determined the prevalence of *Cysticercus cellulosae* in pigs of Jammu region along with determining the role of porcine feed in disease development. A total 600 pork samples were examined and 7 (1.16%) were found positive. Association of porcine cysticercosis with different epidemiological factors was examined, breed and husbandry practices were observed to be statistically linked with disease in pigs. The cyst detected was morphologically analyzed to reveal a scolex with armed rostellum having 27 hooks and four suckers. The suckers and hooks, when subjected to micrometry revealed mean length and width of 273.33 ± 12.12µm and 228.31 ± 9.51µm, respectively, whereas the length of hooks (large and small) were 154.66 ± 10.72µm and 113.33 ± 9.84µm, respectively. Histopathologically the cyst revealed the infiltration of inflammatory cells (primarily lymphocytes) inside and in adjacent, along with marked fibrosis and vasculitis. A total of 25 porcine feed samples including 15 farm feed and 10 sewage samples were screened for *Taeniid* eggs. The observed results revealed that porcine feed is not the major root cause of infection of *Cysticercus cellulosae* for pigs, as only a single sewage sample was found positive for *Taeniid* eggs and egg size observed showed a size of 40.4 ± 4.26µm×28.8±3.02µm on micrometry.

Keywords: Pig, *Cysticercus cellulosae*, micrometry, prevalence, Epidemiology.

Signature of Major Advisor

Signature of the Student

Chapter - 1

INTRODUCTION

CHAPTER - 1

INTRODUCTION

No animal has been responsible for more hypotheses, discussions and errors than the Tapeworm (Davaine., 1860). From the line stated above, the importance and health implications of tapeworms can be understood, one of these tapeworm is *Taenia solium* whose metacestode stage (*Cysticercus cellulosae*) is responsible for cysticercosis in humans and porcine. *Taenia solium* infection (taeniosis) and cysticercosis is a major public health problem, associated with pork consumption in both developed and developing countries (Kumar and Gaur., 1994). It is an emerging disease, with particular importance in immuno-compromised individuals- HIV/AIDS, Severe combined immunodeficiency syndrome etc. There are three obligatory zoonotic species of Taeniidae family which are of immense public importance namely- *T. solium, T. saginata* and *T. asiatica* which act as a health risk in humans and also produce heavy production losses due to animal death. *T. asiatica* is another recognized member of the Taeniidae family, but so far infections related to it have not been reported from India (Ale *et al*., 2014).

Taxonomic classification of *Taenia solium* (Soulsby., 1982).

Domain	Eukariya
Kingdom	Animalia
Phylum	Platyhelminths
Class	Cestoidea
Order	Cyclophilidea
Family	Taeniidae
Genus	*Taenia*
Species	*solium*

The most primitive substantiation to tapeworm was from the documentations (Eber's papyrus) of Egyptians dating back to almost 2000 B.C (Eber's Papyrus). However it is believed that tapeworm described by Egyptians was beef tapeworm because Egyptians never consumed pork (Flisser *et al*., 1954). Aristotle also reported the parasitosis of pork with metacestode of tapeworms in his book the "History of Animal" in 384-323 B.C (Thompson *et al*., 1932). In Indian medicine, cysticercosis has been mentioned in an Indian medical book namely *Charaka Samhita*, as maladies of head. Armstrong in 1888 reported a case of neurocysticercosis for the first time in Madras, India. The affected individual had died from seizures and on autopsying, the cyst were recovered from his brain. Thereafter in 1934, high rate of inception of epilepsy was reported from British army deployed in India (MacArthur., 1934).

Cysticercosis in humans is encountered due to consumption of *Cysticercus cellulosae* from intermediate host (pigs). After intake of the *Cysticercus cellulosae* the protoscoleces of cysticerci evaginate and attach to the mucosal layer of intestinal walls of humans and ultimately matures into the adult tapeworm (*Taenia solium*). It takes approximately 2 months to develop into a mature, reproductively competent, adult tapeworm that is capable of producing eggs (Yoshino., 1934). Adult cestode body has a scolex, a neck and a strobila (Wardle *et al*., 1974). The scolex has four suckers and a rostellum displaying 22-32 characteristic hooks (Wardle *et al*., 1974). The strobila has 700-1000 segments namely- immature, mature and gravid (Pawlowski. 2002). The gravid proglottids detach from strobila through apoplysis usually in groups of 2-5 and are passed in the feces (Pawlowski. 1994).

Being zoonotic in nature, it embraces both human and animal population. Humans as intermediate host acquire infection by accidental ingestion of *Taenia solium* eggs. Porcine cysticercosis is among the most serious zoonotic infestation present universally, even in Muslim and Jewish community where consumption of pork is a religious taboo (Schantz *et al*., 1992, 1993, 1998; Craig *et al*., 1996; Simanjuntak *et al*., 1997; Craig and Pawlowski, 2002). Infection in pigs is primarily due to their scavenging habit which often leads to consumption of human excreta having gravid proglottids containing embryonated eggs of *Taenia solium*. Martinez *et al.* (1997) have reported high prevalence in areas

where there is lack of latrines in >50 per cent of houses and most households allow pigs to roam freely. However pigs can also acquire infection by contaminated hand of feedlot workers, through contamination of feed, soil and even spread by flies or birds (Pathak., 1991). This can be especially problematic in developing countries where pigs are often allowed to roam freely to scavenge for food and where sanitation facilities and hygiene are poor.

The passed eggs are immediately infective to the intermediate host. Accidental ingestion of the eggs by humans and porcine through contaminated food, water and even hands leads to release of oncosphere which penetrate the intestinal mucosa, through circulation migrate and is lodged in different parts of the body namely brain, spinal cord and subcutaneous tissue in humans whereas in pig particularly in cardiac and masseter muscle and form cysts (Garcia *et al*., 1991; Sarti *et al*., 1988; Phiri *et al*., 2002; Flisser *et al*., 2003). It is an ovoid bladder stage with opalescent fluid and the bladder has an outer layer and inner layer (Bon *et al*., 1982). Cyst found in eyes, in brain and throughout body is called as ophthalmocysticercosis, neurocysticercosis and disseminated cysticercosis respectively. In many developing countries, this disease constitutes a serious, sometimes under recognized, public health problem (Tsang and Wilson., 1995).

The socio-economic impact of disease is considerably high both in man and in pigs. The economic losses affecting humans are dual in nature - health hazard caused by neurocysticercosis in humans, economic loss in terms of loss of man hours in diseased individual. The manifestations of NCC are polymorphic indicating that no particular symptom or clinical sign is pathognomic. Symptoms generally observed are headache, hydrocephalus, chronic meningitis, focal neurological deficits, psychological disorders, dementia, ocular and spinal cysts (Chandramukhi and Nayak., 1990; Del Brutto *et al*., 1996; Carpio *et al*., 1998; David and Mathai., 2000). The losses encountered in pork industry are due to condemnation of carcass, decreased acceptability of pork, restriction in export and import of meat due to porcine cysticercosis has been widely reported from all around the globe. Poor sanitation and lack of veterinary control provide the ideal condition to sustain the life cycle of *Taenia solium* (Garcia *et al.,* 1998).

T. solium infection has two clinical manifestation in humans namely - taeniosis and human cysticercosis, taeniosis on one hand even in heavy infection exhibit mild symptoms like abdominal pain, sleep disturbances etc (Pathak.,1991), on the other hand human cysticercosis has a grave clinical picture. Taeniosis acquired by eating raw or partially cooked pork infected with the larval form of *Taenia solium* (Pawlowski., 2002). Human neurocysticercosis, in man occurs when the cysts develop in the brain or spinal cord (Carabin *et al.,* 2009) and is acquired through accidental ingestion of *Taenia solium* eggs along with contaminated foodstuff, vegetable and even through dirty hands. Cysticercosis is widely prevalent in man and pigs in both temperate and tropical region. The disease in pigs is generally asymptomatic and is usually detected at postmortem.

In Indian scenario, the conditions essential for the cysticercosis to thrive are ideal both in livestock and in humans population which are: improper sewage disposal system or even absence of latrine in house of majority of population, free access of pigs to human excreta particularly in pigs reared through free range, lack of awareness regarding the disease and its consequence among public, use of sewage water or water contaminated with human night soil for irrigation which serves as a indirect but potential source of infection for vegetarians.

In 2013-14, the contribution of the Indian livestock industry to GDP was 4.11 per cent and in terms of meat particularly, India produced 8.89 million tones of meat. In India about 20.5 million people depend upon livestock for their livelihood and livestock rearing and associated practices provide income to two third of the rural community (FAO., 2015). Measure to control porcine cysticercosis would not only be beneficial to human health and heath system but also to the national economy both at state and central level. The Work carried out by some of the researchers specifies the importance of disease in human as well as pig population such as: Sharma *et al.* (2004) carried out work in northern Punjab to record the prevalence of swine cysticercosis. The overall prevalence rate was found to be 6.35 per cent, with higher prevalence in pigs under 1year of age. Borkataki *et al.* (2011) estimated the prevalence of porcine cysticercosis in Assam for a year. Total of 978 pigs were examined, out of which 93 pigs (9.50%) were found to be positive for infection. District wise highest (13.70%) prevalence was found in

Karbianglong and lowest (7.55%) in Nagaon district. Age wise prevalence study showed highest (11.41%) in the age group of 7-12 months and lowest (7.60%) in the age group 19-24 months. Infection rate in male and female was 9.15 and 10.39 per cent and in breed prevalence was found more in crossbred (12.53%) than in local breed (7.49%). Overall seasonal prevalence was highest during pre-monsoon (10.93%) and lowest (7.82%) during monsoon season. The epidemiological prevalence's in the above mentioned studies provide sufficient evidence regarding the significant difference in burden of disease in animals in relation to breed and season.

In Jammu, pig farming is mainly a small scale production system. Pigs in such low input system provide value added output to farmers by consuming feed that would otherwise be wasted (Chauhan *et al.*, 2016). The farming is primarily adopted by small scale landless farmer and thus, rearing practices are mainly backyard and are based on market demands (Chauhan *et al.*, 2016). The scavenging habits of pigs and there indiscriminatory feeding habits further reduce their cost of rearing, as maximum feed is either kitchen waste which is of low cost or human excreta or garbage which are essentially useless. Pigs reared through extensive system i.e which roam freely in search of feed, often consume human excreta and leftover waste from garbage dumping grounds. Thus, pig rearing in addition of providing protein for consumption also act as minimum investment industry for poor marginal farmers and provide them the much required financial stability with least monetary inputs.

Diagnosis of disease with precision in intermediate host have always been vital element in selection of epidemiological features to control disease equally in humans and animals. The test employed for diagnosis of infection in porcine are antemortem examination, postmortem examination, serological test and molecular test namely tongue palpation test (helpful in diagnosis in only heavily parasitized swine), postmortem examination of the carcass thoroughly by multiple incision in various organs, ELISA used to detect the circulating antibody in blood of infested pig in serological test and PCR in molecular techniques. However, necropsy is the method of choice.

Cysticercosis has a worldwide occurrence high prevalence has been found in rural areas of endemic countries for example Mexico, Guatemala, El Salvador, Honduras,

Columbia, Ecuador, Peru, Bolivia, Brazil in America, India, SriLanka, Thailand, Malaysia and China in Asia (Schantz., 2002). The disease draws attention considering the findings which demonstrate that people suffering from cysticercosis in India are primarily vegetarians acquiring infection from foodstuff contaminated with eggs of *Taenia solium* (Thakur *et al*., 1991).

In India, porcine cysticercosis has wide geographic distribution as indicated by the various reports on prevalence. The reports indicate that the disease is endemic in Punjab, Maharashtra, Andhra Pradesh, Uttar Pradesh, Bihar, Assam, Gujarat and lowest prevalence record from Jammu & Kashmir state and Kerala state on the ground of Muslim community with majority of population in Jammu whereas in Kerala, high standard of living and public awareness regarding disease is responsible for the low prevalence.

Garcia *et al*. (1999) suggested that determining the percentage of porcine population that is infected is a better epidemiological indicator of *Taenia solium* infection pressure than measuring the infection in human population. Because porcine infection is much more common than the human infection; the life span of pigs in field conditions is much shorter than that of humans and the bleeding of pigs for diagnostic purposes is more easily accepted by pig owners compared to obtaining blood or stool specimens from humans. As per 19th livestock census pig population of Jammu is 3146, out of which 2310 belong to indigenous breed whereas 836 are exotic or crossbred. As no baseline epidemiological study on porcine cysticercosis using conventional parasitological techniques has been carried out in Jammu region of Jammu & Kashmir. Under the light of paucity of epidemiological data or it's underreporting. Taking into consideration the above points, the present study was contemplated to estimate epidemiology of cysticercosis in pigs and factors responsible for the same with the following objectives:

1. To study prevalence of *Cysticercus cellulosae* by using conventional parasitological techniques in pigs of Jammu.
2. To screen the feeding material of pigs for presence of *Taeniid* eggs using conventional parasitological techniques.

Chapter - 2

REVIEW OF LITERATURE

CHAPTER - 2

REVIEW OF LITERATURE

As the systematic states, *Taenia solium* belongs to subclass Eucestoda and family Taeniidae. The family comprise of 11 genera, one of them is *Taenia* which comprise 20 species; important among them are *T. solium* (pork tapeworm), *T. saginata* (beef tapeworm), *T. hydatigena* and *T. pisiformis* (canine tapeworm) (Soulsby., 1982). The adult *Taenia solium* worm generally has a size varying between 2mt-3mt in length, possessing an armed scolex having four sucker which acts as a holdfast organ, neck and strobila consist of 700-1000 of segmented proglottids, encasing an trilobed ovary and testes (Eom *et al*., 1993; Pawlowski., 1982; Goennert *et al*., 1998 and Fan., 1995). The gravid uterus shows characteristic dendritic branching pattern with 7-12 branches (Pawlowski., 1994). The gravid proglottids gradually get detached from worm body through "apoplysis" and are passed out in feces in groups (ranging from 2-5 proglottids) few times a week (Pawlowski., 1994).

The eggs of *T. solium* are morphologically similar to other members of Taeniidae family and cannot be distinguished by direct microscopy. The egg typically ranges from 40 × 30µm in size; consist of an outer shell, embryophore and onchosphere. The embryophore is spherical in shape and has characteristic "cart wheel" appearance. The onchosphere has six armed embryonic hooklets giving it the name "Hexacanth embryo" usually visible through the embryophore (Pawlowski., 2002).

The metacestode stage (*Cysticercus cellulosae*) is a bladder worm, average size of 5.6mm-8.5mm × 3.1mm-6.5mm found both in humans (dead-end host) and pigs (Classical intermediate host) (Yoshino., 1934). The *cysticercus* is an ovoid bladder stage composed of an outer capsule in which an invaginated protoscolex is present along bladder fluid, which in case of mature *cysticercus* is opalescent. The outer capsule of metacestode can be further divided into an outer and inner layer between the layers hair like projections are present. The layers perform twofold function of providing protection and simultaneously facilitate the exchange of nutrients and excretory metabolites. The pig

infected with *cysticercus* if not consumed for meat purpose, the cyst present in it will gradually undergo degenerative changes after few years and eventually forms a calcified granuloma (Pawlowski., 2002).

The biological cycle of disease is relatively simple and indicates that it's a zoonosis consisting of two hosts and the environment. Man, the final host, harbors the tapeworm and passes several thousand eggs. The eggs are disseminated in environment through feces and pigs acquire infection through egg, which later develops into *cysticercus*. Human consuming the infected pork completes the life cycle. Alternative infection (cysticercosis) to man encountered are through consumption of eggs of worm. These termed as external and internal autoinfection wherein external route refer to faeco-oral route and internal is the infection encountered in carrier of *Taenia solium* adult worm. Approximately 5-40% of individual sufferings from taeniosis are reported to acquire cysticercosis, probably by retroperistalisis and poor hygiene practices (Schantz *et al*., 1998). Neglect of hygienic standards after defecation and before consuming meal is principal reasons for external autoinfection (Singh *et al*., 2002). In the present study we studied the prevalence of disease in intermediate host (Swine) and further the importance of their feeding habits in acquiring infection via egg consumption.

Taenia solium has a worldwide prevalence with wide geographic distribution. High infection rates are mainly restricted to low socio-economic countries such as Central and South Africa, Mexico, Central and South America, Southern Asia. In certain areas, disease exists in hyperendemic form for example in Mexico, 1.9% of all deaths is due to cysticercosis and 3.5% of all autopsy performed show *Taenia solium* cysticerci. In southeast Asia , *Taenia solium* appears to occur in most of the countries namely India, Nepal, China, Srilanka, Hongkong, Phillipines, Veitnam (Singh *et al*., 2002).

Despite of significant economic and public health impact of disease, it largely remains as a neglected zoonosis. The impact of which in terms of monetary losses and loss of man power due to morbidity and mortality, not to forget the losses incurred in health sector as cost of treatment remains largely underestimated.

2.1 EPIDEMIOLOGY OF CYSTICERCOSIS

2.1.1 In Swine

In India the estimated pig population is about 10.29 million which constitute 2.01% of the entire livestock population (GOI., 2012). Data collected on porcine cysticercosis from abattoirs in Uttar Pradesh from several locations showed the Prevalence to be 8-12% in muscle in slaughtered pigs (Pathak and Gaur., 1989).

The prevalence of *T. solium* metacestode is varying considerably throughout the world with maximum prevalence recorded from Peru and Guatemala and lowest being found in Europe where the diseases is practically non existent

Swine act as an intermediate host for *Taenia solium* and therefore, play an important role in maintaining and transmission of infection to man. Porcine cysticercosis is widely prevalent and is present throughout the world. The disease in porcine is mainly found in areas where open defecation is practiced by humans. Thus, developing countries such as India, China, and Indonesia are the places where the disease is present in abundance. Few reports in support of the above statement are described below.

2.1.2 Factors Associated with the Disease in Swine

The prevalence and risk factors of *T. solium* associated with pigs were studied in rural population in Michoacan state, Mexico (Sarti *et al*., 1992). The various key factors associated were (i) indiscriminate access to human excreta (ii) absence of an indoor latrine (iii) random disposal of human feces around houses of pig owners.

2.1.3 Work Done in India

Pathak and Gaur. (1989) screened 3550 pigs of different breeds, age and sex from different parts of Uttar Pradesh from 1980 to 1985, for the presence of cysticerci. The overall incidence in pigs was 9.3 per cent. Indigenous breeds brought from rural areas had the highest infection rate with 8.9 per cent.

Deka and Gaur. (1990) investigated the epidemiology of *Taenia solium* cysticerci in 2980 pigs slaughtered in the western parts of Uttar Pradesh, India. The overall

infection in these animals was found to be 15.5 per cent and the highest rate of infection was observed at the Central Dairy Farm, Aligarh with 17.4 per cent.

Sarma *et al*. (2000) determined the occurrence of hydatidiosis and porcine cysticercosis in Guwahati city. The prevalence of hydatid cyst was investigated in 313 cattle, 47 buffalo, 279 pigs, 223 goats at slaughter houses during 1996-1998. During the same period pigs were also screened for *Cysticercus cellulosae*. The infection rate for hydatid cyst was 13.73 per cent, 27.6 per cent, 1.79 per cent, 2.24 per cent in cattle, buffalo, pigs and goats respectively. The prevalence recorded for cysticercosis was 3.22 per cent in pigs.

Hafeez *et al.* (2004) carried out a study by using conventional meat inspection as well as immunodiagnostic tests; like CIEP and ELISA for detection of porcine cysticercosis and its seroprevalence. By classical meat inspection, per cent positivity of 3.52, 5.50, 5.73 and 5.38 were recorded in Andhra Pradesh, Tamil Nadu, Karnataka and Kerala respectively. By CIEP, 6.16, 5.83, 6.04 and 5.69 per cent of sera samples were found positive in Andhra Pradesh, Tamil Nadu, Karnataka and Kerala respectively. By ELISA, 6.50, 6.22, 6.40 and 6.50 per cent of sera samples were found positive in Andhra Pradesh, Tamil Nadu, Karnataka and Kerala respectively.

Sharma *et al.* (2004) carried out work in northern Punjab to record the prevalence of swine cysticercosis and to find out the correlation between the disease and various epidemiological factors. The overall prevalence rate was found to be 6.35 per cent among 236 pig carcasses. Age-wise prevalence was more (6.48%) in younger pigs of <1year of age than those aged >1 year (6.25%). Prevalence rate was found to be 8.82 per cent in males and 4.48 per cent in females.

Prakash *et al*. (2007) carried out a study in order to estimate the level of neurocysticercosis in free roaming pigs- a slaughter house survey. A total of 200 brains were collected from pigs slaughtered at local abattoir, between august 2005- march 2006. Gross and histopathological examination revealed 3 per cent prevalence (6/200) in pigs.

Mandakhalikar *et al*. (2009) studied the prevalence of cysticercosis in pigs and estimated the economic losses caused by condemnation of carcasses. An overall

prevalence of 0.89 per cent was observed with 8 positive carcasses (one carcass showing less than 5 cysts and seven carcass showing more than 5 cysts). Higher prevalence was recorded in males with 0.55 per cent in comparison to female with 0.33 per cent. Maximum positive carcasses recovered were from Jalgaon followed by Surat and Dhule.

Borkataki *et al.* (2011) studied prevalence of porcine cysticercosis in Assam for a year. Total of 978 pigs were examined, out of which 93 pigs (9.50%) were found to be positive for infection. District wise highest (13.70%) prevalence was found in Karbianglong and lowest (7.55%) in Nagaon district. Age wise prevalence study showed highest (11.41%) in the age group of 7-12 months and lowest (7.60%) in the age group 19-24 months. Prevalence of *Cysticercus cellulosae* infection in male and female was 9.15 and 10.39 per cent respectively. Breed wise prevalence was found more in cross bred (12.53%) than in local breed (7.49%).Overall seasonal prevalence was highest during pre-monsoon (10.93%) and lowest (7.82%) during monsoon season. The disease was found to exist in the study area throughout the year that ranged from 5.71 to 14.06 per cent.

Sreedevi *et al.* (2011) screened 225 pig carcasses for cysticercosis by meat inspection in coastal district of Andhra Pradesh, out of which 25 carcasses with visible cysts (16 viable and 9 degenerated cysts) were also confirmed to be positive for cysticercosis by PCR. However, out of the 35 carcasses with suspected lesions on meat inspection, only two were found positive for cysticercosis by PCR.

Saravanan *et al.* (2014) estimated prevalence of porcine cysticercosis in Bareilly. Total of 175 pigs were examined for cysticercosis, out of which 9 (5.14%) were found positive. Sex-wise prevalence of this infection in male and female was recorded as 4.82 per cent (4/83) and 5.43 per cent (5/92), respectively. The infection was higher (5.34%) in the young age group of 1-12 months as compared to the older stocks of 13-24 months of age group (4.54%). Prevalence of porcine cysticercosis was relatively higher in cross bred pigs (5.88%, 6/102) than in the non-descript local breed of pigs (4.11%, 3/73).

Chawhan *et al.* (2015) conducted a study on prevalence and molecular epidemiology of porcine cysticercosis in Punjab. Total of 519 pigs were examined for the

presence of *Taenia solium* cysts on post-mortem inspection at different slaughter shops (shops that sell meat from animals that are slaughtered on the premises as the customer waits) located in urban slums in Punjab. In the study, an apparent prevalence of 4.23 per cent (95% CI 2.8– 6.3%) (22/519) was recorded. The proportion of positive carcasses was found to be significantly higher (chi square = 28.65, p = 0.0001, d.f. = 1) in 192 stray/scavenging pigs (10.41%) than in 327 farm pigs (0.61%).

2.1.4 Work Done in Abroad

Phiri *et al*. (2002) carried out a study to determine the prevalence of porcine cysticercosis in Eastern and South provinces of Zambia. The study involved an abattoir survey of 1316 pigs at Luska and two field surveys in villages in Southern and Eastern province. Lingual examination, visual inspection of carcass and enzyme linked immunosorbent assay were used as parameters. Out of 1316 pigs, 143 (10.9%) and 271 (20.6%) were found positive by lingual examination and meat inspection. The field survey revealed that 8 (8.2%) out of 98 pigs and 8 (5.2%) out of 151 pigs from Southern and Eastern province were found positive respectively. Using Ag-ELISA 20 (20.8%) and 14 (9.3%) were found positive in Eastern and Southern province. The survey revealed poor pig husbandry practices and poor farming are major contributors to high prevalence of disease.

Shey-Nijia *et al*. (2003) carried out a study to determine the prevalence of porcine cysticercosis in two villages and a local meat shops at Batibo, North-West Cameroon. A total of 383 pigs were examined and a prevalence of 4.44 per cent was found positive by tongue palpation whereas by ELISA 27.7 per cent of pig sera were found positive.

Ngowi *et al.* (2004) examined 770 live pigs by lingual examination in 21 villages. Associations between factors were analyzed using Bayesian hierarchical model to obtain prevalence, odds ratio (OR) and 95 per cent Bayesian Credible Intervals (95% BCI). Prevalence was 17.4 per cent (village-specific range 3.2–46.7%). Prevalence of porcine cysticercosis was considerably higher in pigs reared in households lacking latrines than in those reared in households using latrines (OR = 2.04; 95% BCI = 1.25, 3.45).

Boa *et al.* (2006) estimated the prevalence and risk factors for porcine cysticercosis. Overall 722, 808 and 302 live pigs were examined lingually from Chunya, Iringa Rural Districts and Ruvuma Region, Tanzania. Prevalence of swine cysticercosis was found to be 7.6 per cent, 8.4 per cent and 16.9 per cent in different regions respectively.

Jayashi *et al*. (2007) conducted a study to record the seroprevalence and risk factors of *Taenia solium* cysticercosis in pigs of North Peru. A total of 1,153 pigs were sampled. Porcine seroprevalence was 45.19 per cent. In the porcine population, the risk of being seropositive increased by 7 per cent with every month of age (OR 1.07, 95% CI 1.05–1.09), and by 148 per cent for pigs living in East Morropon (OR 2.48, 95% CI 1.82–3.37) whereas, the presence of latrines in a household decreased the risk of being seropositive by 49 per cent (OR 0.51; 95% CI 0.39–0.67). Sex and rearing system did not represent either risk or protective factors associated with the seroprevalence of porcine cysticercosis.

Sikasunge *et al*. (2008) examined a total of 1691 pigs, out of which 183 were found positive with a prevalence of 10.8 per cent and 23.3 per cent with tongue palpation and Ag- ELISA respectively. Statistically (applying logistic regression analysis) breed was the only factor found to be significantly associated with cysticercosis in pigs (OR= 0.72; 95% CI= 0.63-0.81). The crossbred were found to be 72 per cent more likely to have had cysticercosis then local breed (Nsenga) as observed by Ag-ELISA.

Krecek *et al*. (2008) carried out a community based study of porcine cysticercosis in areas owned by resource poor and emerging pig producers in 21 villages in Eastern Cape. Methods employed included tongue palpation, Enzyme linked Immunosorbent assay (ELISA) and enzyme immunotransfer blot (EITB) technique. As per the study results, the disease is present in the area under study and the prevalence recoded was 64.6 per cent with an apparent prevalence of 11.9 per cent for tongue palpation, 54.8 per cent and 40.6 per cent for ELISA and 33.3 per cent for EITB.

Pondja *et al*. (2010) carried out a survey in Angonia district, Tete province in Northwestern Mozambique. A total of 661 pigs were tested serologically (Ag- ELISA)

and examined by tongue inspection. 231 samples were found positive with a prevalence rate of 34.9 per cent serologically and 84 were found positive by tongue inspection with 12.7 per cent prevalence.

Mkupasi *et al*. (2011) carried out to a study to establish the prevalence of extra-intestinal porcine helminth infection and to assess the pig slaughter sanitary conditions in Dar es salaam, Tanzania. A total of 24 slaughter houses and 731 pigs were examined with prevalence rate of 8.1 per cent, 5.9 per cent, 0.4 per cent were infected with ascariosis, porcine cysticercosis and hydatidiosis respectively. Based on region, the status of porcine cysticercosis was 8.2 per cent for Dodoma, 8.2 per cent for Manyara and 6.9 per cent for Mbeya.

Eshitera *et al.* (2012) carried out work in Homa bay district, Kenya to record the prevalence of porcine cysticercosis and associated risk factors. A cross-sectional survey was carried out in 2010, and a total of 392 pigs were recruited in a household survey, with all being tested by ante-mortem lingual palpation together with questionnaire data on pig production, occurrence and transmission of porcine cysticercosis, risk factors. Seventy six pigs were found positive by the Ag-ELISA (32.8%, 95% C.I. 26.8-39.2%), while by tongue inspection cysticerci were detected in 22/ 392 pigs.

Silva *et al*. (2012) carried out a study to record cysticercosis in experimentally and naturally infected pigs by parasitological and immunological diagnosis. Seven (7) pigs were experimentally infected orally with eggs of *Taenia solium* and another 10 were naturally infected. In pigs with heavy natural infection, inspection of the tongue identified cysticerci in two (20%), while at inspection with necropsy the parasites were identified in large quantities in all animals. In ELISA for antibody search (Ab-ELISA) TS-14 recombinant protein was used, and in search for antigen (Ag-ELISA) a monoclonal antibody against this protein. In animals experimentally infected, blood was collected weekly for 140 days. The Ab-ELISA identified an increase in titers of antibody to cysticerci 21 days after infection and at the end of the experimental period six animals (86%) were positive to the test. The search for circulating antigens (Ag-ELISA) was positive in two pigs 28 to 91 days after infection. All naturally infected pigs were positive for Ag-ELISA and Ab-ELISA.

Erick *et al*. (2013) carried out a study to record the porcine cysticercosis and associated risk factors in small holder pig production system in Mbeya region, southern highlands of Tanzania. A cross-sectional survey employing a random sampling of 300 pigs keepers from Mbozi and Mbeya Rural District. Concurrently, 600 pigs were examined for porcine cysticercosis using lingual method of examination and Ag-ELISA. The overall pig prevalence was 11.7 per cent (95% CI=8.5-15.8%) and 32 per cent (95% CI= 27-37.5%) based on lingual examination and Ag-ELISA in Mbeya district whereas in Mbozi the recorded prevalence for porcine cysticercosis was 6 per cent and 30 per cent respectively.

Yohana *et al*. (2013) performed a study on the prevalence of porcine cysticercosis and risk factors for taeniosis in Iringa rural district, Tanzania. A total of 110 households rearing pigs from sixteen villages were involved in a survey in which 308 pigs were examined for *cysticercus* cysts by antemortem and postmortem methods. Of 308 pigs examined by lingual palpation, 7.5 per cent had cysticerci; the prevalence rates were higher in male pigs than female 69.5 per cent and 30.4 per cent respectively. The triceps muscle had the highest number of cysts 51.1 per cent and the diaphragm had the lowest 6.9 per cent.

Zirintunda and Ekou. (2015) estimated prevalence of porcine cysticercosis in free ranging pigs in Arapati, Soroti district, Uganda. Out of 178 pigs examined 32 were positive for porcine cysticercosis representing a prevalence of 18 per cent.

Khaing *et al*. (2015) estimated the prevalence and risk factor of porcine cysticercosis. Overall, 364 pigs were examined from 203 households. The prevalence of porcine cysticercosis through meat inspection was 23.67 per cent and seroprevalance was 15.93 per cent. The significant associated risk factors with *Taenia solium* cysticercosis were gender (OR=3.0,95% CI-1.7-5.4), increased age (OR=2.3;95% CI=1.2-4.2), husbandry system (OR=5.1;95% CI=2.4-11.2), feed type (OR=16.9;95% CI=2.3-124.3), not using antihelminthic (OR=2.5;95% CI=1.4-4.4), no hand washing before feeding (OR=31.5;95% CI=4.3-230.9) and pork consumption of owner (OR=37.4;95% CI=9.0-156.1) in the study area.

Thomas *et al*. (2016) conducted a study in which a total of three hundred forty-three pigs slaughtered and marketed in western Kenya were subjected to lingual examination and HP10 Ag-ELISA for the serological detection of *Taenia solium* antigen. When estimates were adjusted for the sensitivity and specificity of the diagnostic assays, prevalence of *T. solium* cysticercosis estimated by lingual exam and HP10 Ag-ELISA was between 34.4 per cent (95 % confidence interval (CI) 19.4–49.4 %) and 37.6 per cent (95 % CI 29.3–45.9 %), respectively. However, all pigs were reported to have passed routine meat inspection.

Porphyre *et al*. (2016) conducted a study aimed to estimate the prevalence of porcine cysticercosis by meat inspection and serological test among pigs slaughtered in Antananarivo abattoirs, Madagascar. The diagnostic performance of two antigen-ELISA techniques (B158B60 Ag-ELISA and HP10 Ag-ELISA) and an immune-blotting method were compared with meat inspection procedures on a samples of pigs suspected to be infected with (group 1; n = 250) or free of (group 2; n = 250) *T. solium* based on direct veterinary inspection in Madagascar. Then, a third set of pig sera (group 3, n = 250) was randomly collected in Antananarivo slaughter houses and tested to estimate the overall prevalence of *T. solium* contamination in pork meat traded in Antananarivo. The antigen ELISAs showed a high sensitivity (>84%), but the B158B60 Ag-ELISA appeared to be more specific than the HP10 Ag-ELISA (model 1: 95% vs 74%; model 2: 87% vs 71%). The overall prevalence of porcine cysticercosis in Antananarivo slaughter houses was estimated to be 2.3 per cent (95% credibility interval [95%CI]: 0.09–9.1%) to 2.6 per cent (95%CrI: 0.1–10.3%) depending on the model and priors used.

2.2 In Humans

Taenia solium cysticercosis has a worldwide prevalence, but the disease is endemic in poor resource countries or in developing countries primarily Latin America, China, Southern East Asia, Sub-Saharan Africa. A seroprevalence as high as 20 per cent in humans and 37 per cent in pigs has been reported in Guatemala, Bolivia and Peru (Schantz., 2002). The disease has also been included in neglected Tropical disease identified by WHO. In India, the diseases widely prevalent in all states of the country except Jammu & Kashmir state and Kerala state. Several review paper or monographs,

research papers and case reports on human cysticercosis have been published in recent years (Nausheen *et al*., 2013).

Dumas *et al*. (1989) carried out a study in order to evaluate the prevalence of cysticercosis and epilepsy. The study encompassed 5264 subjects over 15 years old, selected using random sampling techniques; 125 cases of cysticercosis were diagnosed with 2.4 per cent prevalence. 12 by anatomo-pathological examination of cysts 18 were based on skull and muscle X- rays calcifications and 104 Patients were identified using ELISA tests on 1527 serum samples (optical density greater than or equal to 0.4). Among 88 epileptic patients (prevalence = 16.7 per 1000), 27 also suffered from cysticercosis (38.7 per cent of all epileptic patients, 21.6 per cent of cysticercosis patients and 0.51 per cent of the total population).

Moore *et al*. (1995) conducted a survey in 9 per cent of household in an orthodox Jewish community who were affected with neurocysticercosis. Cysticercosis antibodies were detected in 23 people out of 1,789 subjects from 612 families with a prevalence of 1.3 per cent. All 23 seropositive were asymptomatic and had intracerebral lesions when went under brain imaging. Seropostivity was associated with female sex (RR= 2.45, P= 0.049), hiring a domestic worker for child care duties (RR = 3.79, P = 0.05) and with employees from Central America (RR = 2.70, P= 0.0001).

Garcia *et al*. (1995) examined multiple socioeconomic, demographic, medical and behavioral characteristics of 946 of Peruvian neurologic patients for a correlation with NCC, which was diagnosed by the highly specific and sensitive electroimmunotransfer blot (EITB) assay. 18 per cent (172/932) of serum samples and 28 per cent (101/362) of cerebrospinal fluid samples were found EITB positive.

Ferrer *et al*. (2002) conducted a study in which he examined the seroprevalence and serum antibody isotype profile for *Taenia solium* Cysticercosis in Amerindian community in the Amazonas state of Venezuela. An Ag-ELISA was used to detect viable cysticercosis. Indirect ELISA and enzyme linked immunoelectrotransfer blot (EITB) was performed by using antigens prepared from *Taenia solium* metacestodes to detect anti-parasite antibodies. The Ag-ELISA and Ab-ELISA revealed 64.7 per cent and 79.00 per

cent seropostivity, respectively in the population. Immunoglobulin m was predominant antibody class, suggesting recent infection.

Kashi et al. (2002) conducted a study in which he studied 72 members of pig farming community and 50 slaughtered pigs in Uttar Pradesh, India. The study was conducted during November 2000 to June 2001 for *Taenia solium* infection. 27 (38%) of the human subjects had intestinal taeniosis and 7 (9.7%) had reported seizures. All 3 of the latter who were examined had neurocysticercosis. 13 (26%) of pigs had cysticercosis.

Rajshekar *et al*. (2003) conducted a seroprevalence study on *Taenia solium* taeniosis in Vietnam, China, Korea and Indonesia. The study revealed a prevalence rate of 0.02-12.6 per cent. Rate of taeniosis, as observed by stool examination for ova, has also been reported to range between 0.1-6.0 per cent in the community in India, Vietnam, China and Indonesia. An astonishingly higher rate of taeniosis of 50 per cent was reported from an area in Nepal populated by pig rearing farmers.

DeGiorgio *et al*. (2005) did a community based sero-prevalence study of *Taenia solium* cysticercosis and *Taenia solium* taeniasis in 449 subjects living in a federally funded and predominantly Hispanic residential community. Along with subjects from two migrant farm worker camps in rural Ventura County, USA was done. The seroprevalence recorded for *Taenia solium* Cysticercosis was 1.8 per cent and the seroprevalence of *Taenia solium* taeniasis by serum immunoblot was 1.1 per cent.

Shanti devi *et al*. (2007) reported a case of 57 year old male presented with recurrent seizures, progressive cognitive deterioration, abnormal gait, headache, impaired vision and multiple subcutaneous nodules all over the body. Cyst in the sub retinal space and lateral rectus muscle of the right eye was seen on fundoscopy and ultrasound examination of the eyeball. CT showed multiple punctuate calcifications with a starry sky appearance. MRI showed multiple cysts in brain, spinal cord, eyes, neck muscle and tongue. The diagnosis made on the basis of microscopic examination of excised nodule was disseminated cysticercosis.

Shukla *et al*. (2010) conducted a seroprevalence study on cysticercosis on population of Lucknow, India. A total of 2500 individuals (including both urban and rural

subjects) were screened by application enzyme linked immunosorbent assay (ELISA) for detecting anticysticercus IgG and IgM antibodies. The overall, urban and rural prevalence rates recorded were 3.48 per cent, 4.64 per cent and 2.32 per cent respectively.

Abdo *et al*. (2010) collected stool samples from 425 patients suffering from gastrointestinal disturbances, in Assuit and Sohage Governates. Stool samples were examined by both direct smear method and sedimentation technique. 92 serum samples were also collected randomly from patients. IgG antibodies against *Taenia solium* and its cysticerci were detected in human serum by using ELISA. The prevalence recorded for taeniosis was 0.7 per cent from 425 patients examined. The seroprevalence recoded on the other hand was 6.5 per cent.

Xu *et al*. (2010) conducted a pilot survey of the seroprevalence of human cysticercosis in Leyte, Philippines by measuring antibody specific for *Taenia solium* cyst fluid antigen. There were 497 subjects aged 7-30 years in the study and most subjects were infected with one or more helminthes. The overall cysticercosis seroprevalence in this population was found to be 24.6 per cent (95% CI: 20.82- 28.85) with no significant difference based on age, sex or helminth co-infection status.

Kashi *et al*. (2011) conducted a study on 595 apparently healthy individuals belonging to the pig farming community of Northern India to estimate the prevalence of asymptomatic NCC based on neuroimaging, immunological and epidemiological criteria. Asymptomatic NCC was detected in 90 individuals with a prevalence of 15.1 per cent.

Sathyanarayanan *et al*. (2011) reported a case of 25 year old male with a history of headache and vomiting. The physical and laboratory examination suggested a diagnosis of tubercular meningitis. However, on the application of high resolution ultrasound imaging of abdomen revealed multiple well defined cyst with scolices. IgG of cysticercosis by ELISA was strongly positive supporting the diagnosis of hepatic cysticercosis.

Surase *et al*. (2011) reported a case of a 22 year old male with a conjuctival cyst belonging to low socioeconomic strata. The mass was then excised and measured 0.4 ×

0.6 cm, was grayish white in color. Histopathology revealed a conjuctival cyst with a parasite embedded in it, showing morphological resemblance to *Cysticercus cellulosae*.

Jayaraman *et al*. (2011) determined the seroprevalence of *Taenia cysticercus* antigens and antibodies in1064 randomly chosen asymptomatic individuals, antibodies to *T. Solium* ova in 197 selected sera and prevalence of taeniasis by a coproantigen test in 729 stool samples. The prevalence of NCC causing active epilepsy in Vellore district was determined in a population of 50617. Coproantigens were detected in 0.8 per cent, Taenia *cysticercus* antigen in 4.5 per cent and Cysticercus IgG antibodies in 15.9 per cent of the population. Cysticercus antibodies were directed against relatively low molecular weight cyst glycoprotein antigens in 14.9 per cent of population. IgG antibodies to *Taenia* ova in 81 of the selected samples. Prevalence of NCC causing active epilepsy was 1.3 per 1000 population.

O'Neal *et al*. (2012) tested stored serum samples from centers of disease control and prevention migrant serum bank for antibodies against *T. solium* cysts by enzyme-linked-immunoelectrotransfer blot. Seroprevalence was found highest among 4 populations namely- Burundi with 25.8 per cent, Burma with 23.2 per cent, Bhutan with 22.8 per cent and Lao people democratic republic with 18.3 per cent.

Raina *et al.* (2012) estimated the contribution of neurocysticercosis (NCC) as a cause for active epilepsy in Jammu. They conducted a door-to-door survey of 2,209 individuals of Bhore Pind and Bhore Kullian villages in Chatha zone of district Jammu to identify patients with symptomatic epilepsy. Patients with active epilepsy were investigated with neuroimaging techniques to establish diagnosis of NCC. Among 25 patients with epilepsy 10(40%) had CT/MRI evidence of past or recent NCC infection. This gave the point prevalence of 4.5/1000 for neurocysticercosis in the study population. The study showed high prevalence of NCC accounting for symptomatic epilepsy in Jammu, Jammu and Kashmir.

Sacchianand *et al*. (2012) reported a case of a 19year old female with disseminated cysticercosis showing cutaneous, neural and ocular nodules. Histopathological features were suggestive of parasitic granuloma with multinucleated

giant cells and eosinophilia along with necrosis. Ultrasonography of lesions indicated multiple well defined cystic lesions of varying sizes. Cranial computed tomography showed bilateral, multiple hyperdense lesions in the supratentorial compartment. All the clinical findings were indicative of *Cysticercus cellulosae* infection.

Bal *et al*. (2012) studied a post-mortem case of 40 year old prisoner. The tissue sample was sent to ascertain the cause of death. The histopathological examination confirmed the presence of a *Cysticercus cellulosae* in brain, liver, kidney and spleen.

Damani *et al*. (2012) reported a case of a 22 year old male presented with the history of lid swelling and chemosis of conjunctiva since 2 days and had a previous history of convulsions. The patient had undergone a CT scan which showed granulomas in temporal and parietal lobes. The patient underwent USG-B scan which revealed cysticercosis cyst in the anterior orbit inferiorly.

Mwang'onde *et al*. (2012) carried out a study to assess the prevalence of human cysticercosis in general public in Mbulu district. The cephalic venous blood was collected from selected community members. Serum extracted from the collected blood was then subjected to *cysticercus* IgG Western Blot Assay for human cysticercosis seroprevalence. The results obtained revealed that about 16.3 per cent of community members had antibodies signifying presence of disease.

Nausheen *et al*. (2013) presented the case report of a 32 year old female from Lucknow, India. The female visited the medicine clinic with the complaint of a painless lump in neck. On examination the mass was 3 x 3 cm in size soft, mobile, not fixed to the overlying skin. The neck mass was surgically removed and sent for histopathological examination which showed milky white cysts containing fluid and a single invaginated scolex. Microscopically the scolex was surrounded by a cyst wall, two suckers were also visible. The cyst wall away from the scolex was thick and thrown into projections. All the features were consistent with cysticercosis.

2.3 Histopathology

Chi *et al*. (1978) carried out a histopathological study on human cysticercosis. They classified them into early, intermediate and late stages. In general, the morphology

of the parasite consisted of a well preserved and compact calcosphercules with intact subcuticular muscle layer in the early stage, showing a progressive deterioration of parasitic structure, finally undergoing resorbptive process or inflammation. The host tissue reaction in the early stages was characterized by a diffuse epitheloid cell proliferation with lymphocytic and eosinophilia infiltration without capsule formation. The intermediate stage consisted of a diffuse histocytic proliferation with well formed outer collagen capsule. The late stage revealed mostly thinned out, well collagenized capsule with scanty lymphocytic infiltration. The parasite in the well formed cyst as usually distorted and often mummified. However the hooklet were relatively preserved up to later stages.

Molinari *et al*. (1983) studied cell reactions to the larva (*Cysticercus cellulosae*) in naturally parasitized, immunized hogs. In hogs naturally infected with *Taenia solium* larvae (i.e., *Cysticercus cellulosae*), they studied the host response induced by antigens obtained from the larvae. Histopathological studies of cysticerci removed after 4 and 8 weeks of immunization showed an intense inflammatory reaction surrounding the larvae. The response was greater in the 1week specimens. A dense layer of eosinophils was in close contact with the external membrane of the bladder wall and in several cases, the eosinophils had infiltrated this tegument. Many eosinophils were seen in the spiral canal of larvae. This infiltration by eosinophils increased with time. Preparations from the 1week samples showed many degenerated and disrupted eosinophils whose granules were found in close contact with the outer membrane of the larval tegument and in some cases, had entered through the broken surface of this structure. More than 90% of the larvae were found in various stages of degeneration; the rest were completely destroyed and surrounded by a mass of eosinophils. After immunization, peripheral blood eosinophilia increased to 17 per cent, whereas the eosinophilia of the control hog was 4% throughout the study. The larval worms removed from control hogs showed intact structures, with a low degree of infiltration by eosinophils and a discrete inflammatory reaction surrounding the bladder wall of the larvae.

Vijayasarathi and Seshadri. (1984) examined 127 dog carcasses and 4 had *Cysticercus cellulosae*. Cysts were in the cerebellum in all the four cases. In 2 cases,

cysts were seen in cerebellum and in one case in diencephalon and medulla oblongata as well. Cysts were also seen in skeletal muscle and cardiac musculature in all the four cases and in visceral organs in two dogs. Histologically the cyst was clearly demarcated from surrounding brain tissue by a chronic inflammatory reaction with mononuclear cell infiltration. Neuronal changes observed were glial cell proliferation and perivascular cuffing indicating that cysticercosis is not just a space occupying lesion.

Aluja *et al*. (1988) conducted a study describing the tissue reaction caused by the larval stage of *Taenia solium* in muscles on samples obtained from 28 infected pigs of different ages and provenance. Results revealed that a total of 296 larvae were observed, 58 had degenerated, causing a severe granulomatous reaction in the host tissues (Grades 4 and 5) and finally fibrosis (Grade 6). Twenty-eight showed no inflammatory response (Grade 0). Judging from the histological findings, the eosinophil seems to be the determinant cell for the initiation of the destructive process of the larvae of *T. solium*. The results also suggest that a greater number ($P<0.01$) of degenerated larvae may be found in older pigs. Four months after infection, the pigs were humanely killed and all tissues were inspected. The brains were extracted and macroscopic examinations were performed to detect external parasites.

Aluja *et al*. (1989) conducted a study in which he investigated five pigs with neurocysticercosis through computed tomography. The pigs were euthanized and the corresponding lesion in their brain were identified and processed for histopathology. It was found that the hypodense areas in CT scans corresponded to vesicular larvae that were presumably viable. The hyperdense areas were either solid in nature or had formed a rim around a hypodense centre and in the brain slice they were either solid granulomas or colloidal cysts with inflammatory reaction in the periphery, perivascular cuffing and vasculitis.

Kumar *et al*. (1991) conducted a study where he studied the host response to *Taenia solium* cysticercoids in naturally infected pigs, slaughtered in Uttar Pradesh, India. Degeneration and necrosis were noticed in infected organs and infiltration of host cells (lymphocytes and eosinophils) was evident in most cases. In tongue, larger cyst were observed with outer layer of cyst wall had thickened in infected brain. Areas of

calcification around the cysticerci were also noticed. A granulomatous reaction had occurred around cysts in the liver and lungs.

Amatya and Kimula. (1999) conducted a study where in sixty two biopsy samples were found positive out of 23,402 biopsies done at Ptan hospital. Most of the patients (82 per cent) were presented with solitary skin nodules, another 10 per cent with nodules in the oral mucosa and 8 per cent in the breast. The average size of cyst was 19mm diameter, and the histological findings showed fibrous walled cysts covered by several layered epitheloid cells without caseous necrosis.

Alvarez *et al*. (2002) conducted a study in which the pig was used as a model to characterize the immune response against cysticerci, given the difficulties in analyzing the developing immune response in infected human brains. Metacestodes in different stages of viability or degeneration were isolated from the brain, heart and skeletal muscle of naturally infected swine, and the adjacent tissue was examined histopathologically. The immune response elicited by the cysticerci was classified into four separate stages. In stage I the parasites were surrounded by a thin layer of collagen type I and by stage II there was a sparse inflammatory infiltrate. In stage III, granuloma formation was evident and by stage IV the parasite was surrounded by an eosinophil-rich infiltrate and its vesicular membrane had begun to degenerate. The final stage IV was detected mainly in the heart but not in the brain. The granulomatous reaction in swine resembled that described previously in human patients, but differed in the abundance of eosinophils, the relative paucity of plasma cells, and the discrete deposition of collagen.

Londoño *et al*. (2002) did a study to determine the histological features of the immune response in swine. The presence of mononuclear cells and eosinophils and the colonization of MCH-II with B-lymphocytes and monocyte and macrophages within the granuloma surrounding the parasites, were features that closely resembled the description made in prior studies with human specimen. In addition, there were novel findings such as upregulation of adhesion CD44 in cells resembling monocytes/macrophages, eosinophils and astrocytes from the central nervous system. The upregulation of CD44 may be important for the recruitment of inflammatory cells to the site of the lesion.

Finally, the presence of null-gamma delta-T cells since stage I of the immune response were similar to early detection of these cells in mouse model for cysticercosis.

Perez *et al*. (2002) conducted a study wherein immunochemistry was used to examine the type of lymphocytes in muscle cysticercosis in naturally infected pigs. The inflammatory response was classified into lesions of grade 1, 3 and 5. In grade 1, a minimal inflammatory infiltrate consisting of eosinophils and a few mononuclear cells, the immunostaining showed more CD4+ cells than CD8+ cells and IgM cells was seen. In grade 3, when granulomatous reactions has not yet developed and the destruction of the parasite began, CD4+ cells and IgM were the predominant cells, although CD8+ cells showed a noticeable increase. In grade 5, with a few parasitic structure surrounded by an extensive granulomatous reaction, lymphocyte subsets were decreased in number and did not show differences from grade 1 except for IgM+ cells, which remained increased. The organization of an active inflammatory response against the metacestode of *Taenia solium* in pigs includes the sequential participation of CD4+, CD8+ and IgM+ lymphocytes.

Dametto. (2016) conducted a study on histopathology of cysticercosis in human brain, the larval stage of *Taenia solium* and surrounding nervous tissue were evaluated by immunohistochemistry using anti-CD3, anti-CD20, anti-CD68, Masson's trichrome, and hematoxylin eosin stain. Photography registered histological details. The microscopy of NCC's lesions presents fibrosis, gliosis, perivascular infiltrate, edema, vascular changes, granulomatosis, and calcification. The cyst's microscopy allows identifying capsule with microvilli and osmotic canaliculli, as well as parasite head with filaments and muscular structures. Immunohistochemistry demonstrates cells responsible for antigen-antibody reactions and wound-repair. Abnormalities in the nervous tissue and parasite characteristics permit diagnosis and explain pathologic mechanisms within NCC's lesion, particularly in chronic inflammation. The protection of neurons recruits chemical mediators, immunological cells (lymphocytes, plasma cells, macrophages) and wound-repair cells (fibroblasts, giant cells, epitheloid cells and glial cells).

2.4 Morphology

Boa *et al*. (1995) examined eighty three carcasses of pigs at three abattoirs in Moshi, Arusha, Mbulu in northern Tanzania. *Taenia solium* larvae were found in all three abattoirs with an overall prevalence of 13.3 per cent. The mean number of protoscoleces were 27 and the length of hooks varied from 105µm to 130µm while that of larger hooks varied from 168µm to 174µm confirming that the cyst were metacestode of *Taenia solium*.

Fan *et al*. (2001a) studied the morphology if *Cysticercus cellulosae* in pigs. In 364 evaginated *Cysticercus cellulosae* in pigs, the mean length and mean width of scolex, proglottid and bladder and diameter of rostellum and suckers were 826×747 µm, 5,370×1,734 µm, 2,885×3,002 µm, 155µm and 253µm respectively. In the protoscoleces, the mean number of segments was 33. Each *cysticercus* had 2 rows of rostellar hooks on the scolex and the mean length and width of inner and outer hooks were 151×18 µm and 117×14 µm.

Fan *et al*. (2001b) determined the growth and development pattern of rostellar hooklet of *Taenia solium* cysticerci (Zhenghuoz and Harbin strains) in three pigs 89-196 days post experimental infection. A total of 3,675 cysticerci were collected from the 3 pigs and 3,007 of 3,675 cysticerci were evaginated by enzyme method. Four hundred and thirty nine evaginated cysticerci were carefully examined and measured after dehydration, staining and mounting on the microscopic slides. Among 439 cysticerci, 234 had paired rostellar hooks and 57 had no hooks including 34 hooks were completely dropped and in 23 no hooks developed. The number ranged from 10-17 pair for paired hooks and 1-29 unpaired ones. Moreover, cysticerci with paired and unpaired rostellar hooks had only one small hook and no hooks were present on their scolices. However, cysticerci with only large (inner row) hooks were not found. The morphological characteristics of these two parasites are very similar. The protoscolex of cysticerci of Taiwan *Taenia* has a sunken rostellum while that of classical *Taenia saginata* only has an apical pit. In addition the rostellar hooks of Taiwan *Taenia cysticercus* is surrounded by two rows of rudimentary hooklet whereas the structure is rarely found in *Taenia saginata*.

Eom *et al*. (2002) collected six adult tapeworms from people of the Zhuang minority residing in the southern part of China (Luzhai isolate). The tapeworm was comparatively analyzed with other tapeworm from people: *Taenia asiatica* (South Korea), *Taenia solium* (People Republic of China). Experimental infections with a hooklet less scolex and with wart like formations on the external surface on the bladder wall. There were rostellar protrusions in the scolices of adult worms. Random amplified polymorphic DNA analysis using arbitrary primers produced bands identical to those of the Korean *Taenia asiatica*.

2.5 Environmental Source of Infection.

Keilbach *et al*. (1989) conducted a study in a Mexican village. In the study, 400 soil samples and 600 flies were examined for the presence of *Taenia* eggs by sedimentation technique and direct examination. The screened samples (both of soil and flies) were found negative for eggs of *Taenia solium*.

Diaz *et al*. (1992) carried out a study in Peru. In the conducted study five soil samples and five river water samples were examined for *Taenia* eggs using sedimentation technique. All the screened samples were found to be negative for eggs.

Chapter – 3

MATERIALS AND METHODS

CHAPTER – 3

MATERIALS AND METHODS

3.1 Place of research work

The research work was carried out at the department of Veterinary Public Health and Epidemiology and Veterinary Parasitology, Faculty of Veterinary Sciences and Animal Husbandry, SKUAST-J, R.S. Pura, Jammu. The period of study was during the year 2016-2017.

3.1.1 Study area

The study was conducted in and around Jammu. The area is located 332 meters above mean sea level, between 74º 50º east longitude and 30º 40º north latitude. The climate is hot, humid and subtropical

3.2 For prevalence of *Cysticercus cellulosae* by thorough postmortem examination in pigs of Jammu.

3.2.1 Sample collection

A total of 600 pork samples were examined for the presence of *Cysticercus cellulosae* for the present study. Monthly visits were made to the local slaughter shops for postmortem examination of pigs. The carcasses were examined visually, palpated and incised at the time of slaughtering (Thornton and Gracy., 1974). The distribution of samples collected with respect to different epidemiological variables – age, sex, breed, management and season is demonstrated in table 1, table 2, table 3, table 4 and table 5 respectively. Samples suspected positive for *Cysticercus cellulosae* were brought immediately to the lab in a sterile polythene bag (Plate 1). The suspected samples were then examined morphologically and microscopically for identification and simultaneously organ predilection was determined. As a part of sampling itself two pig farms were visited in Jammu region. The location of the first farm was Bhour camp, Chatha and the second one was located in Sohal, Akhnur. Breeds reared in farms were –

Desi and crossbred. The farming practices observed there were semi intensive system and extensive system of management respectively. In semi intensive system of management farm premises was fenced, had two sties and animals were stall fed. Males and females were reared together although nursing sow along with their litter was separated to prevent any injury to the piglets whereas in extensive system pigs were reared in free range. They were left loose to scavenge for the day time and were brought back at night and kept in fenced area. The feed mainly involved kitchen leftovers and also army langar leftovers which were brought to the farm every morning. Natural breeding method was followed and farrowing occurs twice annually with a litter size of 6-8 for desi breed and 8-10 for crossbred. In farm with semi intensive system of management, pigs were slaughtered at the age of 12- 14 months at a body weight of 100kg for crossbred animals and 50 kg for desi breed. Farm with extensive system of management sold pigs for slaughter purpose at the age of 7-8 months when they attained 45-50kg of body weight.

Table 1: Age wise distribution of pork samples examined.

Age group	**No. of samples examined**
<1yr	383
>1yr	217

Age grouping was based on questioner survey from workers in meat shops and questioner survey from the farm owner regarding management practices.

Table 2: Sex wise distribution of pork samples examined.

Sex	**No. of samples examined**
Male	367
Female	233

3.2.1.1 Breed in Jammu

Breeds present in Jammu are- Desi breed and crossbred. Desi breed reared in Jammu is petite in structure with black spots present throughout the body (Plate 2) whereas the crossbred reared in Jammu has pink skin with sparse white hair (Plate 3). Stock of crossbred was brought from Punjab as per farm owner.

Table 3: Breed wise distribution of pork samples examined.

Breed	No. of samples examined
Desi	187
Crossbreed	413

3.2.1.2 Management system

In Jammu, organized pig farming is absent. Pig husbandry in Jammu, is mainly an occupation of poor marginal farmers which see pig rearing as quick money. Thus, pig rearing practices primarily being followed here are semi intensive (Plate 4) and extensive system of management (Plate 5).

Table 4: Management wise distribution of pork samples examined.

Management system	No. of samples examined
Extensive	206
Semi intensive	394

3.2.1.3 Seasons of Jammu

As per the Indian Meteorological Department Pune, Jammu has 4 seasons namely- summer, monsoon, post monsoon and winter. The months included in each season are described as follow. Summer includes March, April, May and June. Monsoon includes July and August. Post monsoon includes September, October and November whereas winter included December, January and February.

Table 5: Season wise distribution of pork samples examined.

Season	No. of samples examined
Summer	138
Monsoon	164
Post monsoon	127
Winter	171

3.2.2 Statistical Analysis

The data collected so was then statistically analyzed by applying Chi square, Odds ratio with 95% confidence interval and P value with the help of Ms excel and Java stats.

Formula of the statistical parameters applied on collected data

$$\textbf{Chi square} = \frac{\Sigma(\,observed\ value - expected\ value)^2 \times 100}{Expected \text{ value}}$$

$$\text{Odds. Ratio} = \frac{\text{Animals exposed to risk and diseased} \times \text{Animals unexposed to risk and not diseased}}{\text{Animals exposed to risk and non-diseased} \times \text{Animals unexposed to risk and diseased}}$$

3.2.3 Reagent used for preparing permanent mount of *Cysticercus cellulosae*

a) Formalin – 10%

- Formaldehyde (40%) 25ml
- Distilled water 75ml

b) Absolute Ethanol

- Ethanol 99.9%
- Methanol 0.05
- Iso propyl alcohol 0.01
- Water 0.1

c) Conc. HCl (M= 36.46g/ml)

- Assay (HCl) ≥35%
- Sulfate (SO_4) ≤0.0005%
- Sulfite (SO_3) ≤0.001%
- Free chlorine (Cl_2) ≤0.0001%
- Heavy metal (as Pb) ≤0.0005%
- Iron (Fe) ≤0.0001%

d) Aqueous Borax Carmine Stain

e) Cedar wood oil

- Wt/ml at 20ºc 0.980-0.990g
- Refractive index 1.510-1.521

f) Canada balsam

- Wt/ml at 20ºc 1.0g
- Refractive index (at 25º) 1.52-1.541

3.2.4 Preparation of permanent mount of *Cysticercus cellulosae*.

Standard parasitological technique with slide modification was followed for the preparation of permanent mount of *Cysticercus cellulosae* (Zajac and Conboy., 2012). The steps involved are thoroughly described below:

Step 1: Collection of cyst from positive pork samples

Positive pork samples was incised fiber by fiber and visible cysts were separated and placed in petridish with water before fixing them (Plate 6).

Step 2: Fixation of Metacestode.

a) The chemical used for the fixation of metacestode was 10% formalin. The specimen was placed between two clean microscopic slides in a stretched position, taking enough consideration to avoid application of excessive pressure which may disrupt the structure of metacestode.

b) The slides were held together by tying them at either end by thread.

c) The entire preparation was then placed overnight in jar of fixative (Plate 7).

Step 3: Staining of Metacestode

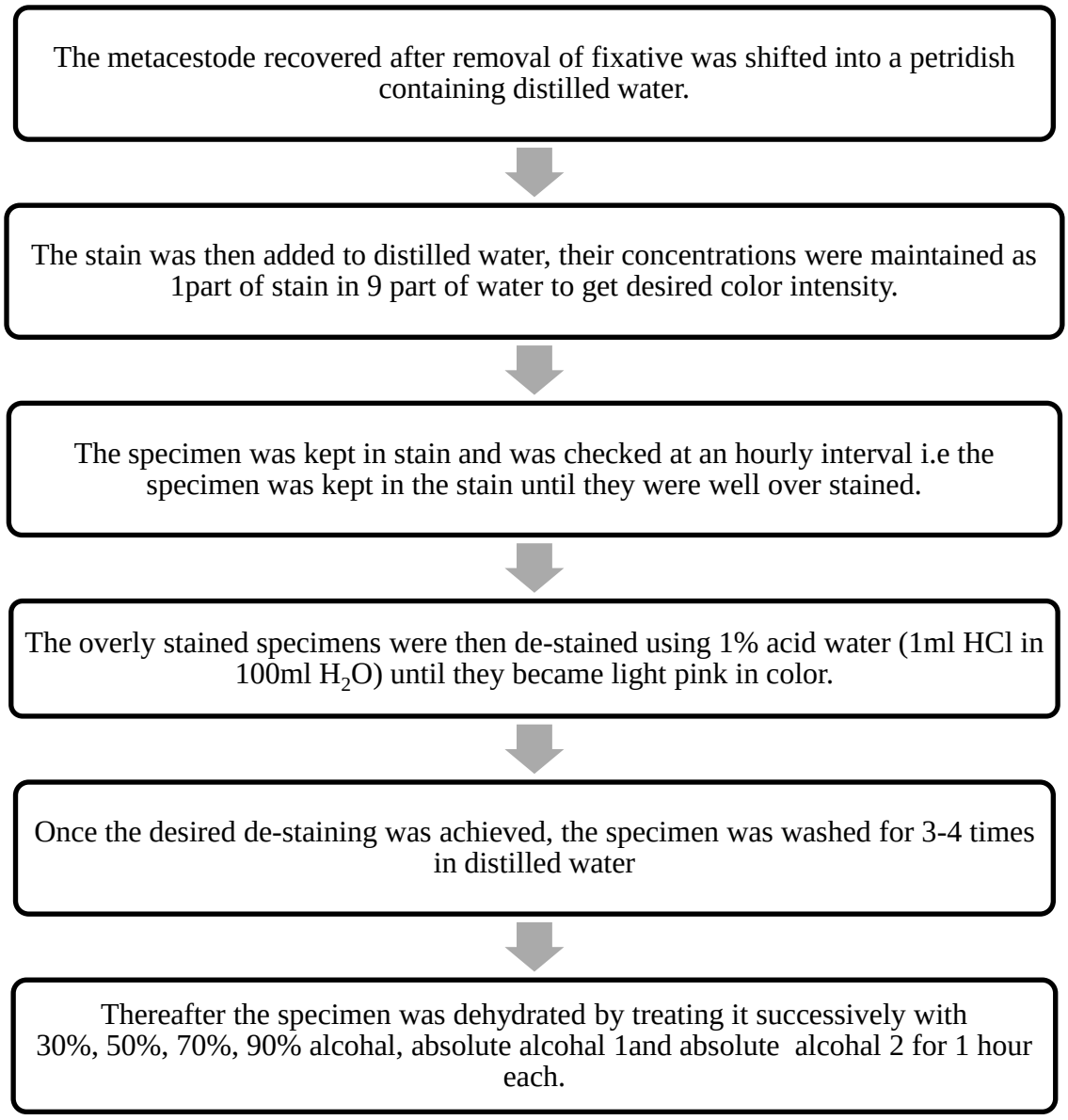
a) Stain used for purpose was Aq. borax carmine.

b) Before placing the metacestode in the staining solution, it is necessary to remove all the traces of the fixative otherwise it will interfere with staining.

c) For this purpose, the specimen was placed in a beaker and the mouth was tightly secured with a muslin cloth.

d) The whole assembly was then placed under slowly running tap water overnight.

After removal of fixative, the steps followed are stated below:



Step 4: Clearing of the metacestode

The metacestode was cleared by placing it in a petridish having cedar wood oil. When cleared, metacestode sank at the bottom of the petridish.

Step 5: Mounting of metacestode in Canada balsam

After clearing the metacestode of *T. solium*, it was given a quick wash in xylene and was mounted in Canada balsam.

3.2.5 Micrometry of *Cysticercus cellulosae.*

Micrometric measurement of *Cysticercus cellulosae* was done, to determine the size of the rostellar hooks and suckers (Zajac and Conboy., 2012).

3.2.6 Histopathological Examination of positive tissue samples.

Positive tissue samples collected were histopathologically examined to demonstrate the interaction of parasite with surrounding tissue. The procedure followed for histopathological examination is described below.

In the present study, positive tissue samples preserved in 10% formalin were processed by routine paraffin embedding (Luna., 1968).

↓

After few days of fixation, the tissue was washed in running water for 7-8hrs, dehydrated in ascending grades of ethyl alcohal, cleared in benezene and embeded in melted paraffin wax.

↓

The prepared paraffin blocks were then incised into section of 5µ with the help of microtome.

↓

The paraffin embedded sections were then passed through sequential steps of deparaffinizing by dipping them in xylene followed by dehydration, achieved by passing the sections through descending grades of ethyl alcohal to tap water

↓

The deparaffinized and dehydrated tissue is then stained by Hematoxylin and Eosin stain and finally mounted on canada balsam to prepare a permanent slide.

↓

The slides stained with Hand E stain were then observed under microscope and pathological changes were observed and recorded.

3.3 For screening of feeding material of pigs for presence of *Taenid* eggs by using conventional parasitological techniques.

A total of 25 **(**15 farm feed samples and 10 sewage samples) porcine feed samples (table 6) were collected periodically in a sterile polythene bags and were brought to the lab the very same day for further processing (Plate 8). Collected samples were processed further for detection of *Taeniid* eggs.

Table 6 -No. of feed samples screened for *Taeniid* eggs

Feed samples	**No. of samples**
Farm feed samples	15
Sewage samples	10
Total	**25**

3.3.1 Qualitative examination.

The flotation method followed for examination of feed samples was in accordance with the procedure of Zajac and Conboy. (2012).

3.3.1.1 Concentration method

Simple flotation technique

a) 5gm of feed was mixed with saturated salt solution in a pestle and mortar.

b) After thorough mixing, the material was sieved and filled in a plastic tube up to the level of brim of tube till it formed a convex meniscus.

c) Then a cover slip was gently placed over the tube and the assembly was left as such for a brief period (15-30minutes).

d) Then the cover slip was removed from the tube and placed over a clean glass slide and was observed under microscope at 10x and 40x.

Centrifugal floatation technique

a) 5gm of feed material was mixed with water in a pestle and mortar.

b) After through mixing and sieving, the material was collected in a centrifuge tube and was centrifuged at 1500rpm for about 3-5 minutes.

c) The upper two third supernatant was discarded and sediment was mixed with small amount of saturated salt solution.

d) More and more saturated salt solution was added in the tube till a convex meniscus was formed at the brim of the centrifuge tube.

e) After meniscus formation, a clean cover slip was placed on the menisci formed over the tube and the assembly was left undisturbed for 25-30 minutes.

f) After which the cover slip was gently removed and placed over clean glass slide and observed under microscope (10x, 40x).

3.3.2 Micrometry.

The eggs detected in feed samples by centrifugal floatation technique were then subjected to micrometry, to determine their size. Micrometry is very helpful in identifying very unusual parasite or is helpful in differentiating organism which are similar in structure but vary in size. Procedure followed for micrometry is described below (Zajac and Conboy., 2012).

Step 1: At first the diameter of microscopic field was established with the help of the micrometers namely- ocular and stage micrometer (Plate 9). Ocular micrometer is a circular glass disc with microscopic graduations etched on its surface which fits into the eyepiece of microscope. The other one is the stage micrometer which was clipped to the stage of microscope. The stage micrometer in its centre has a 1mm distance etched into 100 equally spaced divisions making each division equal to 10µm.

Step 2: The graduations on the ocular micrometer were calibrated against the standard graduations on stage microscope by superimposing one over the other. Thus calibration factor was determined.

Calibration factor for one division on ocular micrometer (in µm) = (known distance between two lines on stage micrometer**)** / number of division on ocular micrometer.

Step 3: After calibration, the egg size was measured by first counting the no. of spaces as per ocular micrometer occupied by it. Thereafter the no. of spaces occupied was multiplied by calibration factor obtained above to determine the egg size.

Chapter – 4

RESULTS

CHAPTER – 4

RESULT

4.1 Prevalence of *Cysticercus cellulosae* by thorough postmortem examination in pigs of Jammu.

Out of 600 pork samples examined at different meat shops in area of Gangyal, Chatha, R.S.pura in Jammu, 7 pork samples were found positive (Plate 10) for the presence of *Cysticercus cellulosae*, with an overall prevalence of 1.16 per cent as shown in table no. 7 and figure 1. In the present study, a prevalence of 1.50 per cent (4) for Gangyal, 1.15 per cent (2) for Chatha and .60 per cent (1) in R.S. Pura was recorded as shown in table no. 8 and figure 2. In the present study, *Cysticercus cellulosae* detected were grossly small spherical to oval in shape were mainly white in color, with a collagenous capsule. The cyst recovered from pork samples had translucent cyst wall along with an invaginated scolex and bladder fluid, the scolex appeared as a small solid granule placed eccentrically. In the conducted study, the organs predilection for the presence of *Cysticercus cellulosae* in pig were found to be thigh muscle, shoulder and muscle of neck region, where the cyst was found in all 7 positive carcasses. Out of the 7 positive carcasses none of the carcasses showed presence of cyst in heart.

Table 7: Overall prevalence of *Cysticercus cellulosae* in pigs of Jammu

Total no. of Samples examined	No. of Positive Samples	Positive Percentage
600	7	**1.16**

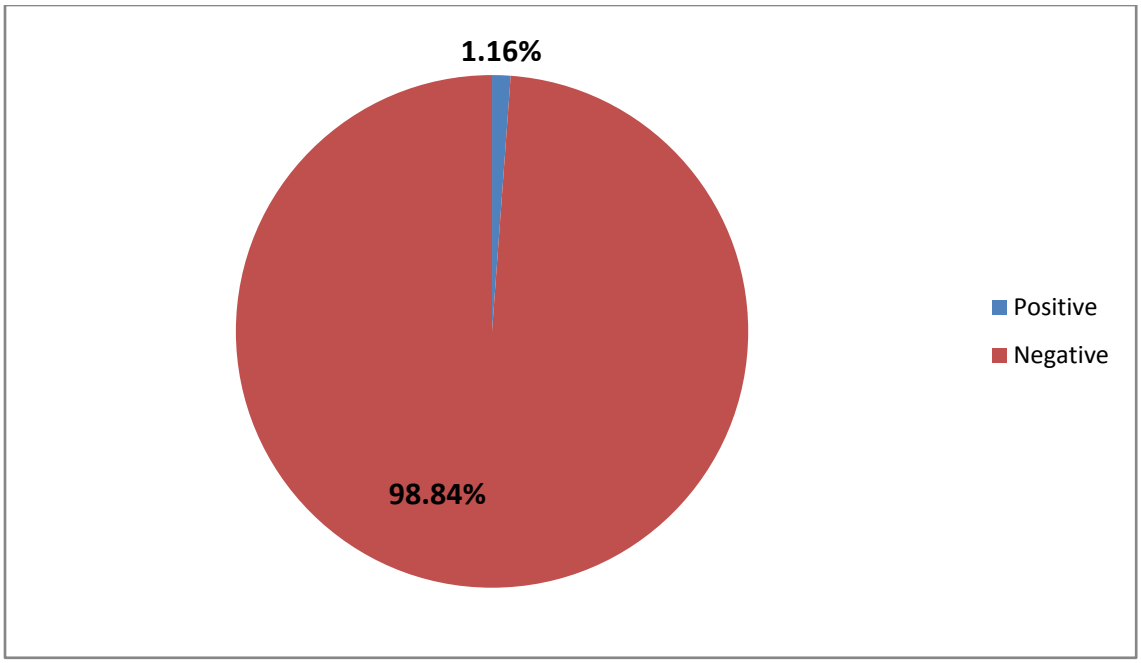


Figure 1: Overall prevalence of *Cysticercus cellulosae* in pigs of Jammu

Table 8: Area wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Area	No. of samples examined	No. of positive samples	Positive percentage
Gangyal	262	4	**1.50**
Chatha	173	2	**1.15**
R. S. Pura	165	1	**0.60**
Total	600	7	**1.16**

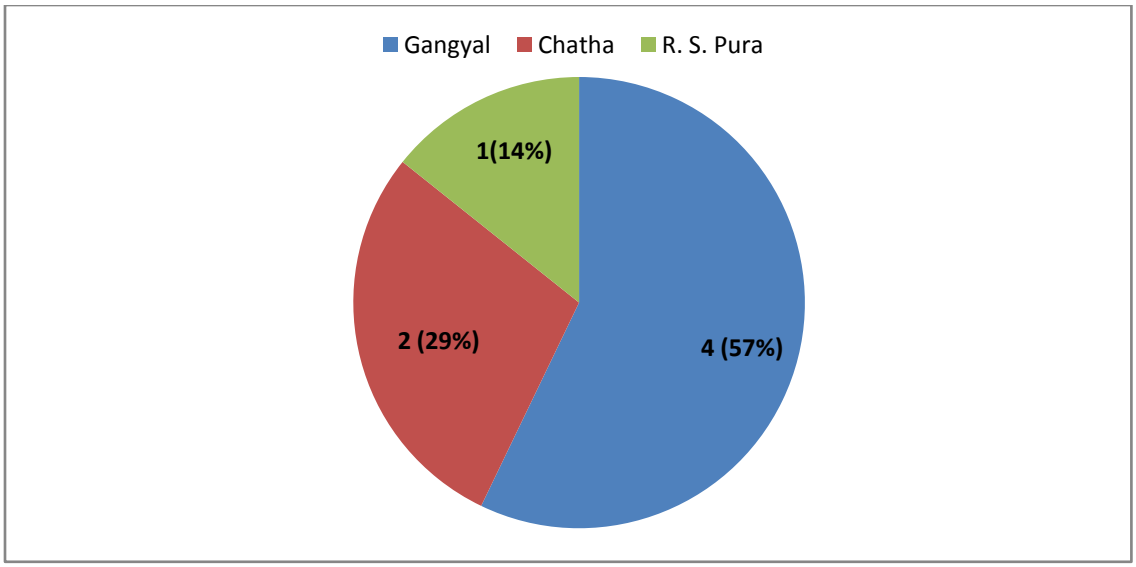


Figure 2: Area wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

4.1.2 Association of porcine cysticercosis with various epidemiological factors.

4.1.2.1 Age

The age wise prevalence recorded to corresponding age group was 1.04 per cent (<1yr) and 1.38 per cent (>1yr) respectively as shown in table no. 9 and figure 3. When the data in table 10 was subjected to statistical analysis, the value derived by applying chi square, odds ratio and P value were 0.137, 0.75 (95% CI= 0.166- 3.39) and 0.071 which is far less than the standard table value (3.841; $p<0.05$) at one degree of freedom. Thus, indicating that the disease distribution is independent of age of animal.

Table 9: Age wise prevalence of *Cysticercus cellulosae* in pigs of Jammu.

Age	No. of samples examined	No. of Positive samples	Positive percentage
<1yr	383	4	**1.04**
>1yr	217	3	**1.38**
Total	600	7	**1.16**

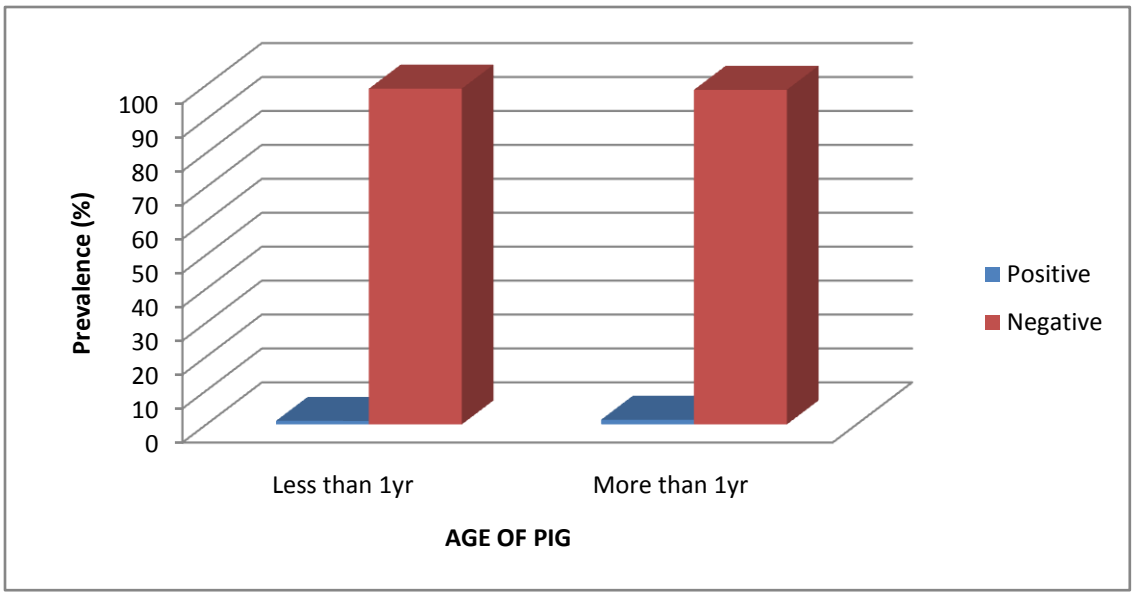


Figure 3: Age wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Table 10: Statistical Analysis Based on Age

Age	Positive	Negative	Chi square	Odds ratio 95% CI	P value
< 1year	4	379	0.137	0.75 (CI= 0.166- 3.39	0.071
>1 year	3	214			

4.1.2.2 Sex

Sex wise prevalence recorded was 1.36 per cent in males and 0.85 per cent in females respectively as shown in table no.11and figure 4. When the data depicted in table 12 was subjected to chi square, odds ratio and P value. The value derived was 0.314, 0.84 (95%CI= 0.18-3-80) and 0.575 for chi square, odds ratio and P value respectively, which is very low in comparison to the table value (3.841; $p<0.05$) at one degree of freedom. Thus, representing that the disease distribution is not significantly associated with sex of animal.

Table 11: Sex wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Sex	No. of samples examined	No. of Positive samples	Positive percentage
Male	367	4	**1.36**
Female	233	3	**0.85**
Total	600	7	**1.16**

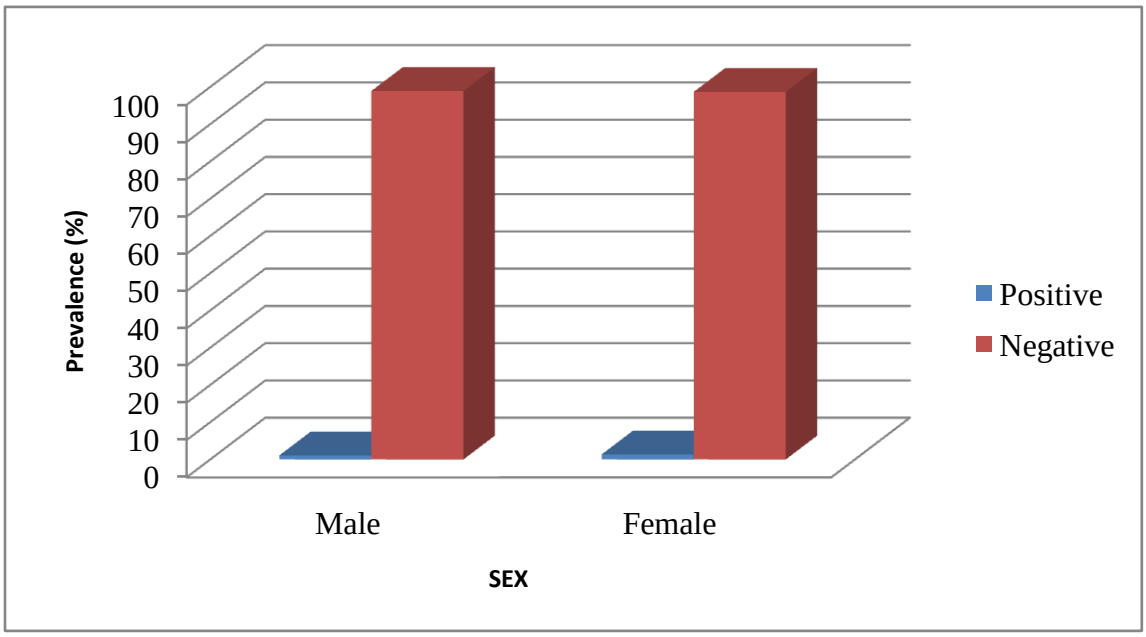


Figure 4: Sex wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Table 12: Statistical analysis based on Sex

Sex	Positive	Negative	Chi square	Odds ratio 95% CI	P value
Male	**4**	**363**	**0.314**	**0.84 (CI= 0.18 - 3.80)**	**0.575**
Female	**3**	**230**			

4.1.2.3 Breed

The prevalence was found to be 2.67 per cent in desi breed and 0.48 per cent in crossbred animal respectively as shown in table no. 13 and figure 5. The data depicted in table no. 14 was subjected to statistical analysis via chi square, odds ratio and p value. The value derived was 4.322, 4.87 (95% CI= 1.037- 25.35) and 0.036 for chi square, odds ratio and P value respectively, which is more than table value (3.841 $p<0.05$) clearly indicating an association between disease distribution and breed of pigs. Thus, the disease prevalence is dependent on the breed of pig.

Table 13: Breed wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Breed	No. of samples examined	No. of Positive samples	Percentage
Desi	187	5	**2.67**
Crossbred	413	2	**0.48**
Total	600	7	**1.16**

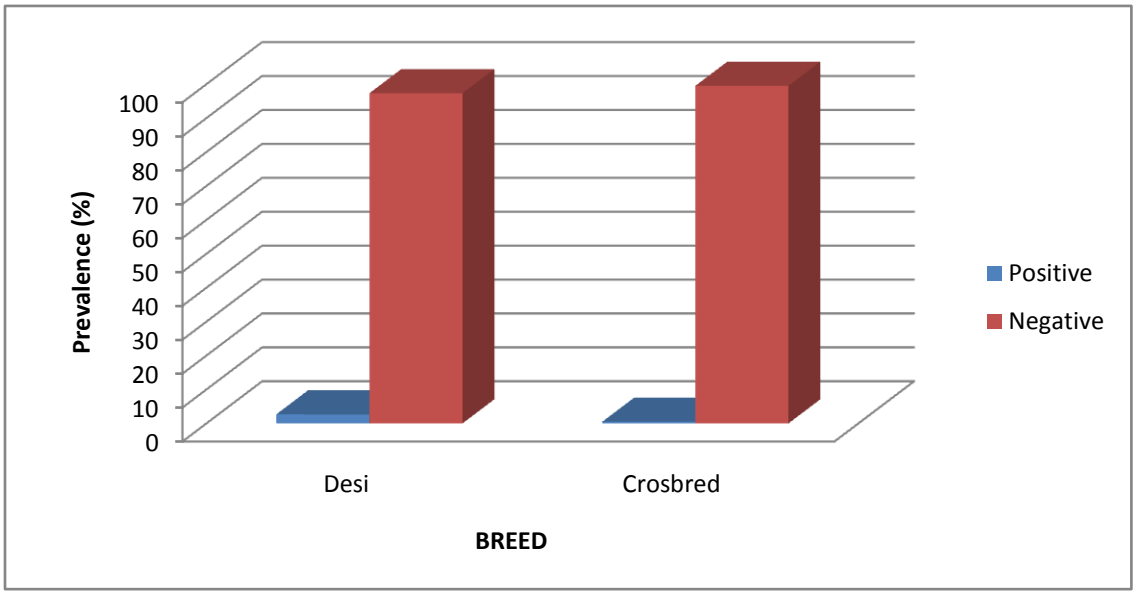


Figure 5: Breed wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Table 14: Statistical Analysis Based on Breed

Breed	Positive	Negative	Chi square	Odds ratio 95% CI	P value
Desi	**5**	**182**	**4.322**	**4.87 (CI= 1.037 – 25.35)**	**0.036**
Crossbred	**2**	**411**			

4.1.2.4 Management system

The prevalence for semi-intensive system was recorded was 0.50 per cent and 2.42 per cent in extensive system of management as shown in table no.15 and figure 6. When the data depicted in the table 16 was subjected to statistical analysis by applying of chi square, odds ratio and P value. The value derived was 5.351, 5.64 (95% CI= 1.8-29.37) and 0.02 for chi square, odds ratio and p value respectively, which is more than the standard table value (3.841; $p<0.05$) indicating a positive association between the disease prevalence and management system.

Table 15: Management system wise prevalence of *Cysticercus cellulosae* in pigs of Jammu.

Management system	No. of samples examined	No. of Positive samples	Positive percentage
Extensive	394	5	**2.42**
Semi intensive	206	2	**0.50**
Total	600	7	**1.16**

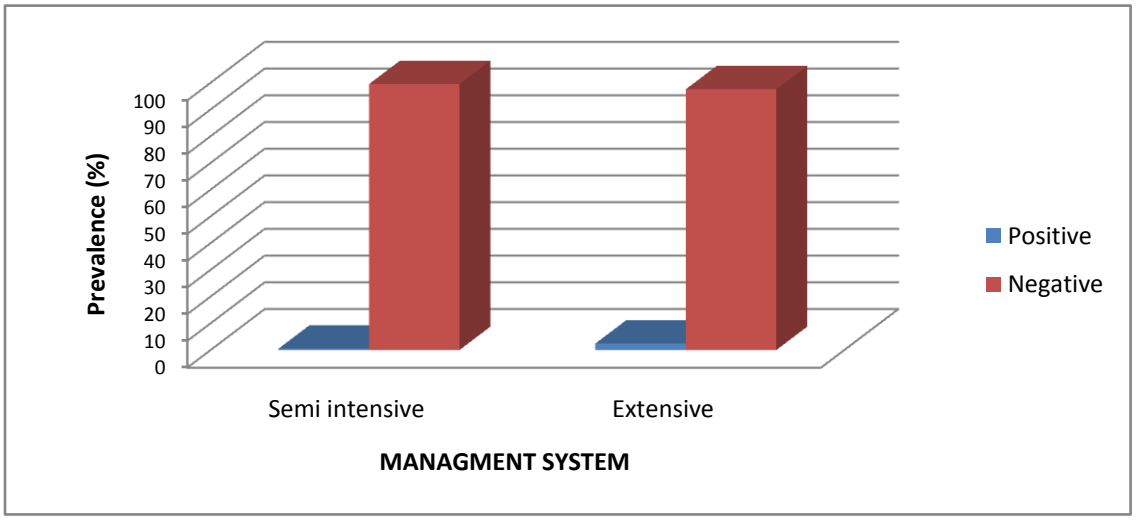


Figure 6: Management wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Table 16: Statistical Analysis Based on Management system

Management	Positive	Negative	Chi square	Odds ratio 95% CI	P value
Extensive	**5**	**201**	**5.351**	**5.64(CI= 1.08–29.37)**	**0.02**
Intensive	**2**	**392**			

4.1.2.5 Season

Season wise prevalence recorded for *Cysticercus cellulosae* was 0.72 per cent in summer, 1.21 per cent in monsoon, 2.36 in post monsoon and 0.58 per cent in winters as shown in the table 17 and figure 7. Highest prevalence was recorded in post monsoon (2.36%) and lowest was recorded in winters (0.58%). The data depicted in table 18, when analyzed showed value lower than the standard table value (3.814; $p<0.05$) which clearly depicts that there is no correlation between the two variable.

Table 17: Season wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Season	No. of samples examined	No. of Positive samples	Positive percentage
Summer	138	1	**0.72**
Monsoon	164	2	**1.21**
Post monsoon	127	3	**2.36**
Winter	171	1	**0.58**
Total	600	7	**1.16**

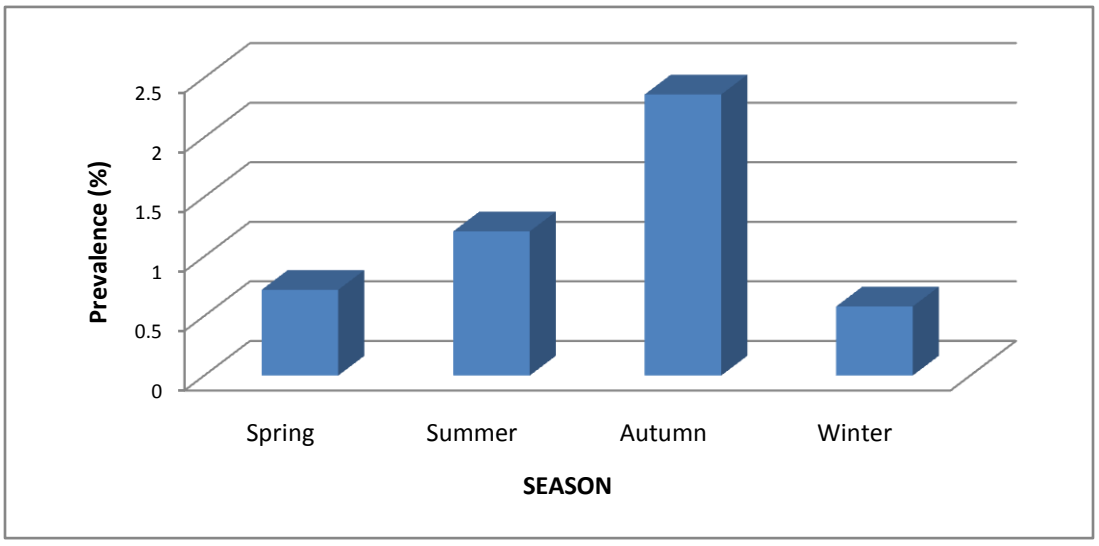


Figure 7: Season wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

Table 18: Statistical analysis based on Season

Season	Positive	Negative	Chi square	Odds ratio 95% CI	P value
Summer	**1**	**137**	**2.314**	**0.30(CI= 0.031-2.93)**	**0.509**
Monsoon	**2**	**162**		**0.51(CI= 0.08-3.10)**	
Post monsoon	**3**	**124**		**-**	
Winter	**1**	**170**		**0.24(CI= 0.02-2.36)**	

(Taking prevalence in Post Monsoon as reference value, Odds ratio for summer, monsoon and winter were calculated)

4.1.2.6 Month

Month wise prevalence was highest in October (3.63%) where as very few cases were reported in summer and winter as shown in table 19 and figure 8.

Table 19: Monthly prevalence of *Cysticercus cellulosae* in pigs of Jammu.

Month	No. of samples examined	No. of Positive samples	Positive Percentage
May	54	0	**0**
June	51	1	**1.96**
July	52	1	**1.92**
August	48	0	**0**
September	51	0	**0**
October	55	2	**3.63**
November	52	1	**1.92**
December	48	1	**2.08**
January	45	0	**0**
February	49	0	**0**
March	49	1	**2.04**
April	46	0	**0**
Total	600	7	**1.16**

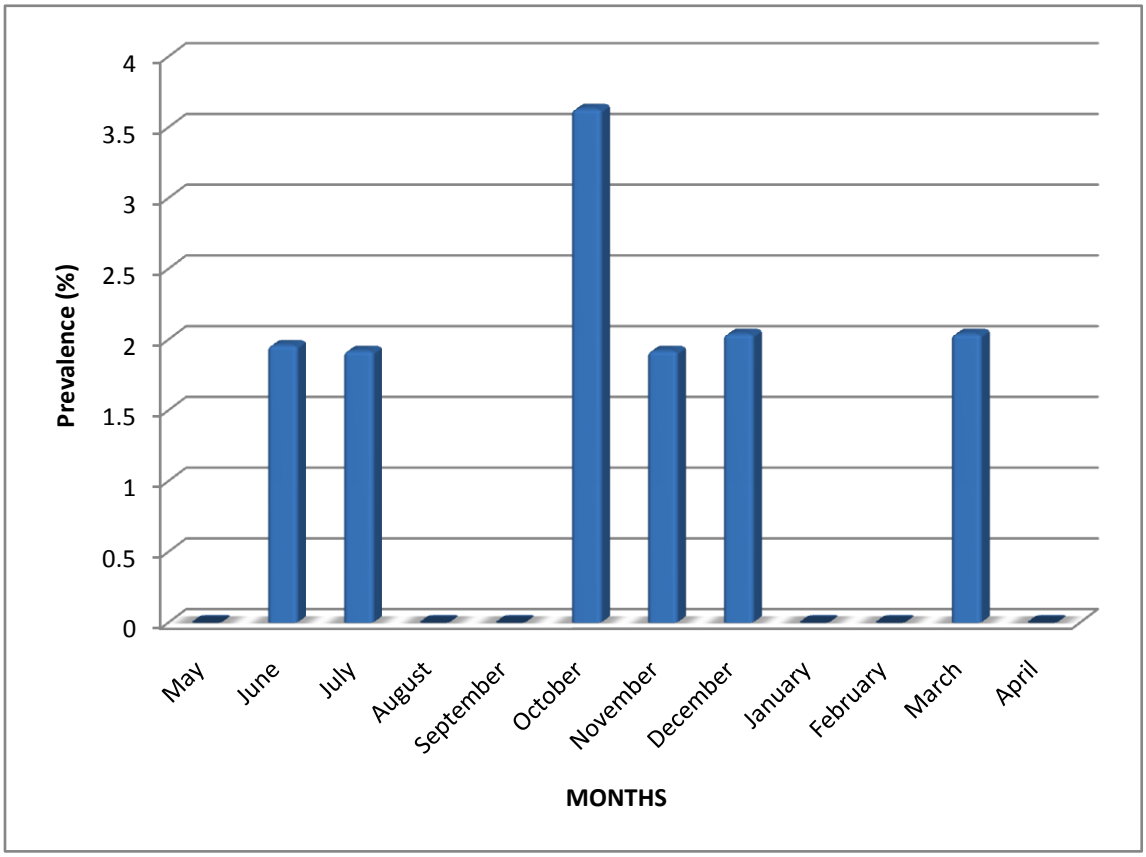


Figure 8: Month wise prevalence of *Cysticercus cellulosae* in pigs of Jammu

4.1.3 Morphological examination of cyst.

The muscle and visceral organs of the each animal included in the study were examined visually, palpated and incised. The affected organs were separated from the carcass and were examined for the presence of cyst. Grossly no inflammatory response was recorded in the tissue present adjacent to cyst. **Grossly,** cyst extracted were spherical to oval in shape ranging from 0.8 to 1.4 cm in size, were mainly white in color with a translucent membrane (Plate 11).

Table 20: Number of cyst recovered from each positive pork sample.

Samples	No. of cysts recovered / 250g of infected pork
1	**28**
2	**19**
3	**17**
4	**15**
5	**13**
6	**18**
7	**14**
Total	**124**

4.1.4 Microscopic examination of cyst.

Microscopic examination of cysts revealed the presence of four suckers and two rows of rostellar hooks in the scolex (Plate 12 and 13). The shape of sucker was round with mean length and width recorded for suckers – 273.33 ± 12.12 and 228.33 ± 9.51µm.

The double rows of rostellar hooks consisted of a row of small and large hooks arranged alternately. Number of hooks varied from cyst to cyst with an average of 27 hooks per cyst. The measurement of hooks is described in table 21 and the hooks were characteristically divided into blade, guard and handle (Plate 14).

Table 21: Measurement of total no. and length of hooks

Total no. of hooks		**Total length of hooks in µm**	
Large	**Small**	**Large**	**Small**
11-14	9-12	154.66 ± 10.72	113.33 ± 9.84

4.1.5 Histopathological examination of tissue samples for *Cysticercus cellulosae*.

On histopathological examination of tissue samples, pathological changes observed were divided into two categories which are described below:

Pathological changes seen in tissue surrounding the cyst- the skeletal tissue showed lymphocytic infiltration and fibrosis in muscle connected to the core of the cyst (Plate 15). An interesting finding was the presence of vasculitis characterized by perivascular fibrosis and congestion (Plate 16). Perivascular fibrosis was more pronounced in blood vessels present adjacent to the cyst. Vasculitis is primarily caused by massive leukocyte migration which ultimately damages the blood vessel causing inflammatory changes.

Histopathological changes observed in *Cysticercus cellulosae* - The histopathological section displayed intact cyst with a bladder wall and scolex. Inside of cyst characterized by presence of spiral canal, hooklets and well preserved vesicular membrane (Plate 17). The parenchymatous portion of the cyst can be seen along with extensive fold of spiral canal.

The pathological changes encountered - the cyst was in early second stage of degeneration characterized by fibrosis of outer membrane and presence of inflammatory cells along the outer covering (Plate 18). Inside the larvae infiltration of inflammatory

cells was observed, with lymphocyte population being the highest followed by macrophages followed by scanty plasma cells (Plate 19).

4.2 Screening of feeding material of pigs for presence of *Taeniid* eggs.

Out of 25 screened samples (15 farm feed + 10 sewage samples) one sewage samples was found positive for *Taeniid* eggs and was detected by application of centrifugal flotation technique as shown in table 22.

Table 22: No. of feed sample found positive for *Taeniid* egg

Feed samples	No. of samples taken	Positive Samples
Feed samples from pig farm	**15**	**0**
Sewage samples	**10**	**01**

4.2.1 Morphology of eggs.

The eggs observed were oval in shape had an outer shell with an embryophore and with embryo inside. The embryophore was thick, globular in shape and striations were present throughout the embryophore giving it a characteristic cart wheel appearance (Plate 20). Inside the embryophore oncosphere was present with six typical embryonic hooklets (“hexacanth embryo”).

4.2.2 Micrometry of eggs detected.

The *Taeniid* eggs observed varied in size but an average size 40.4 ± 4.26µm × 28.8 ± 3.02µm was recorded.

Plate 1-Collection of pork samp

Plate 2- Desi breed reared in Jammu

Plate 3- Crossbred reared in Jammu

Plate 4- Pig Farm, Chatha, Jammu (Semi intensive system)

Plate 5- Pigs consuming sewage, Chatha, Jammu (Extensive system)

Plate 6- Squeezing the *Cysticercus cellulosae* between the slides

.

Plate 7-Fixation of *Cysticercus cellulosae* by placing it in formalin

Plate 8- Feed sample collected in a sterile cup

Plate 9- Ocular (O) and Stage (S) micrometers.

Plate 10- *Cysticercus cellulosae* in pig muscle (thigh muscle)

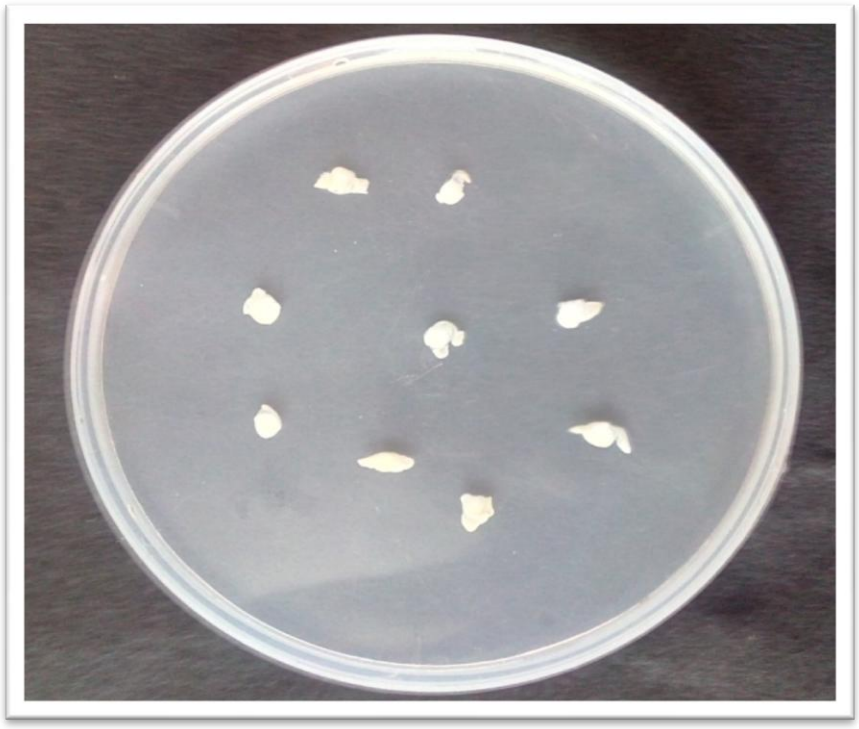


Plate 11- Collected *Cysticercus cellulosae* in petridish

Permanent mount of *Cysticercus cellulosae* stained with Aq. Borax Carmine

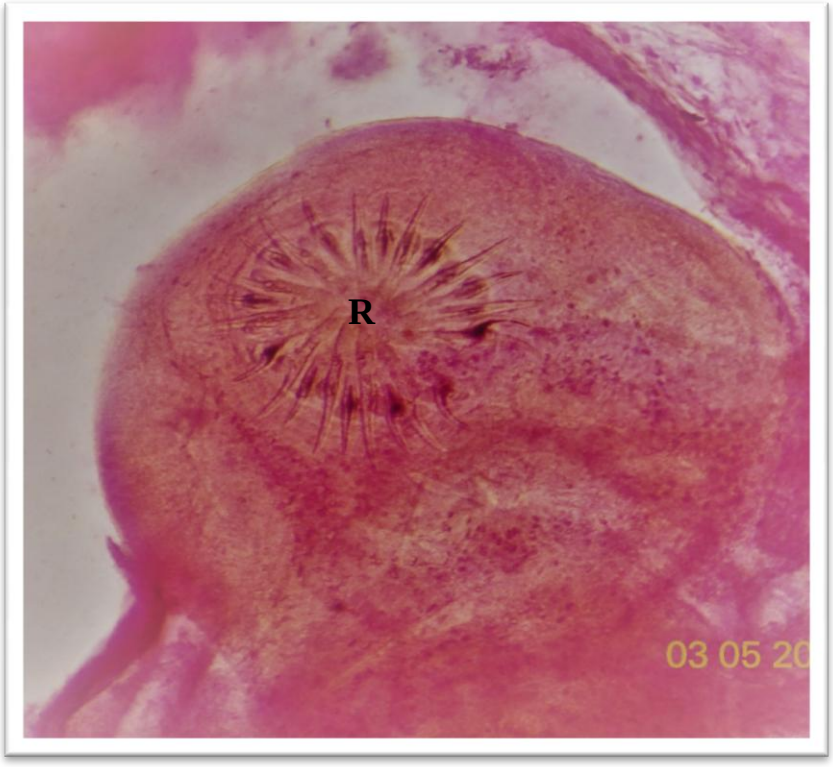


Plate 12- Showing intact armed rostellum (R) (Large & Small hooks)

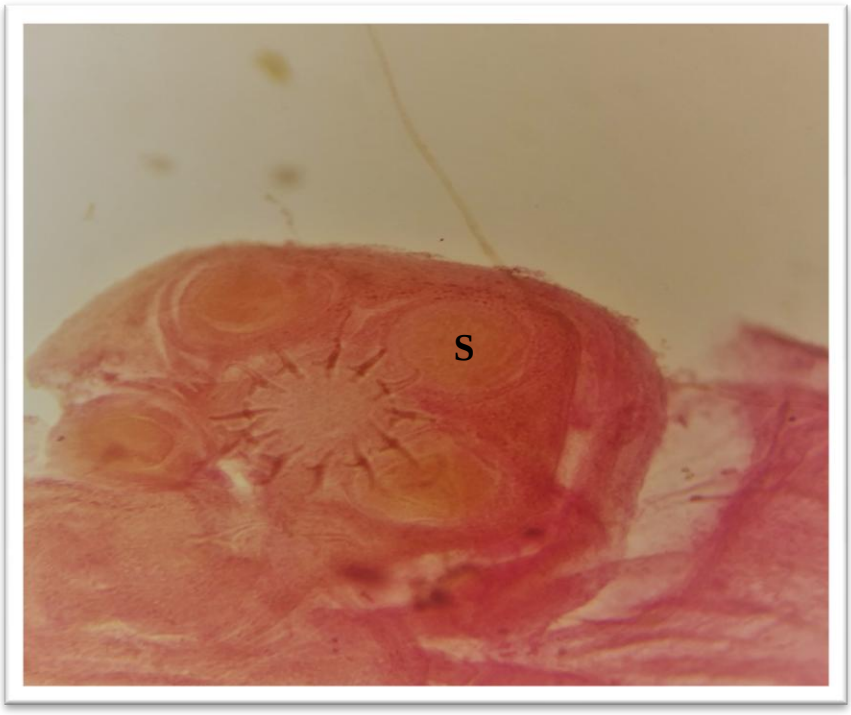


Plate 13- Showing four suckers (S) with armed rostellum

Plate 14- Rostellar hooks showing Blade (B), Guard (G) and Handle (H)

Tissue section stained with Haemotoxylin and Eosin

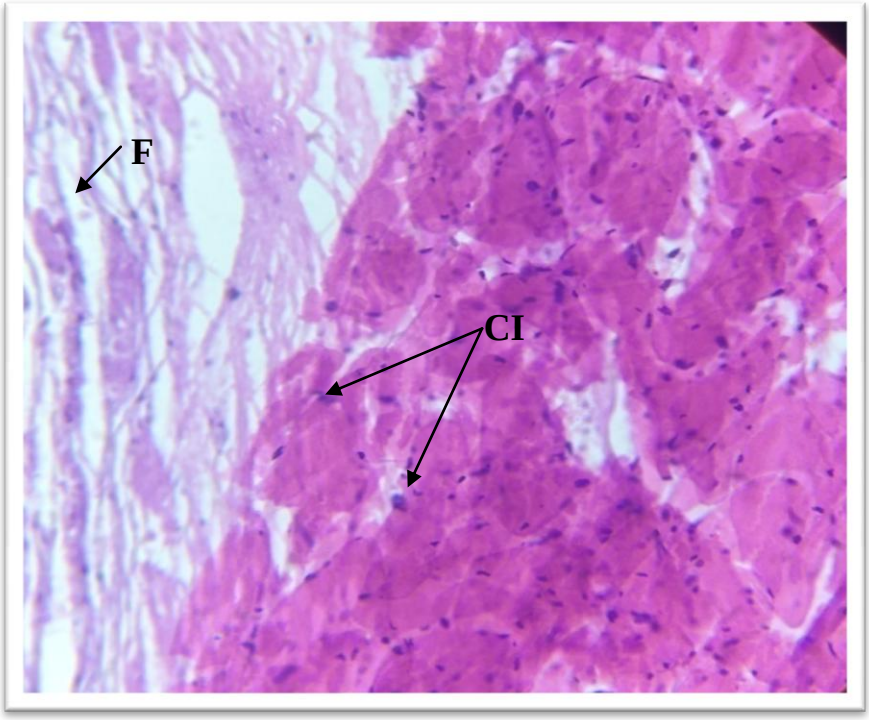


Plate 15- Showing fibrosis (F) and cell infiltration (CI) in adjacent skeletal tissue

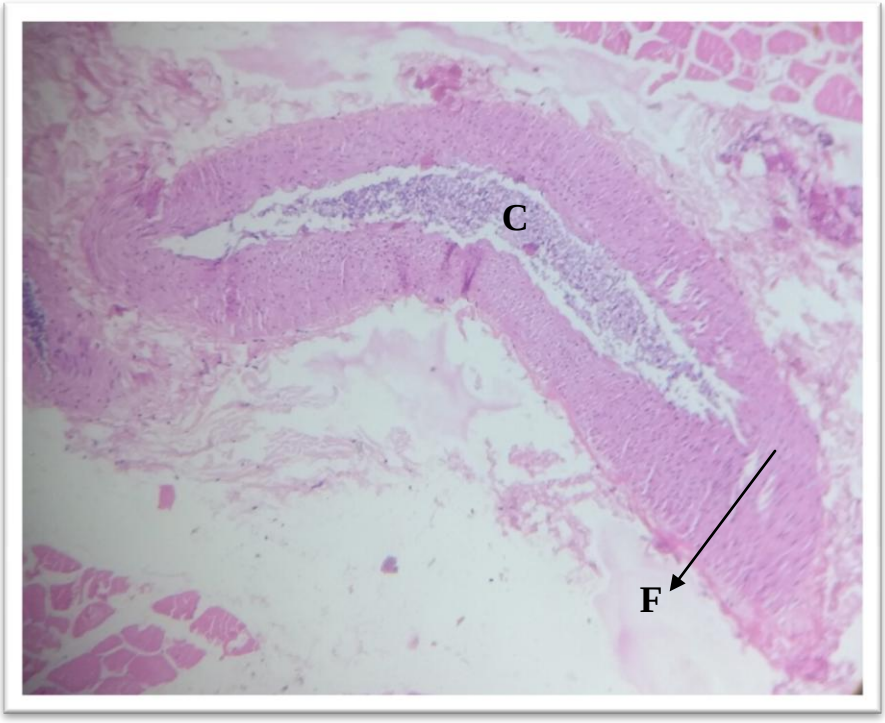


Plate 16- showing vasculitis with perivascular fibrosis (F) and congestion (C)

Tissue section stained with Haemotoxylin and Eosin stain

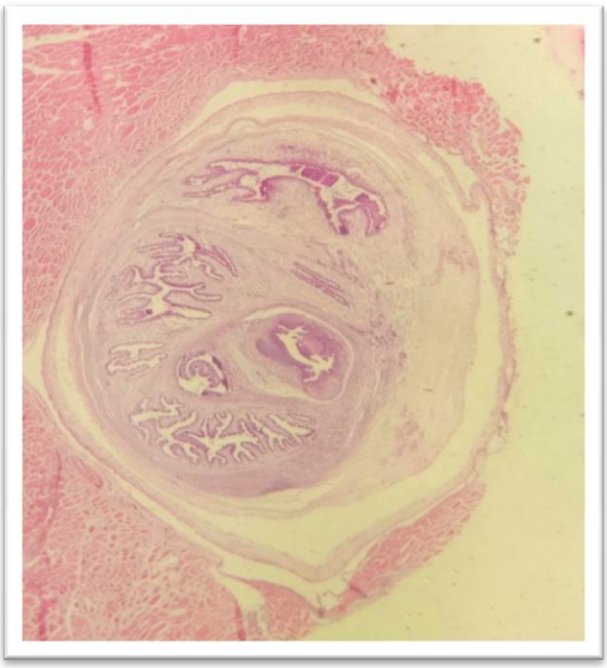


Plate 17- Intact *Cysticercus cellulosae* in stained skeletal muscle

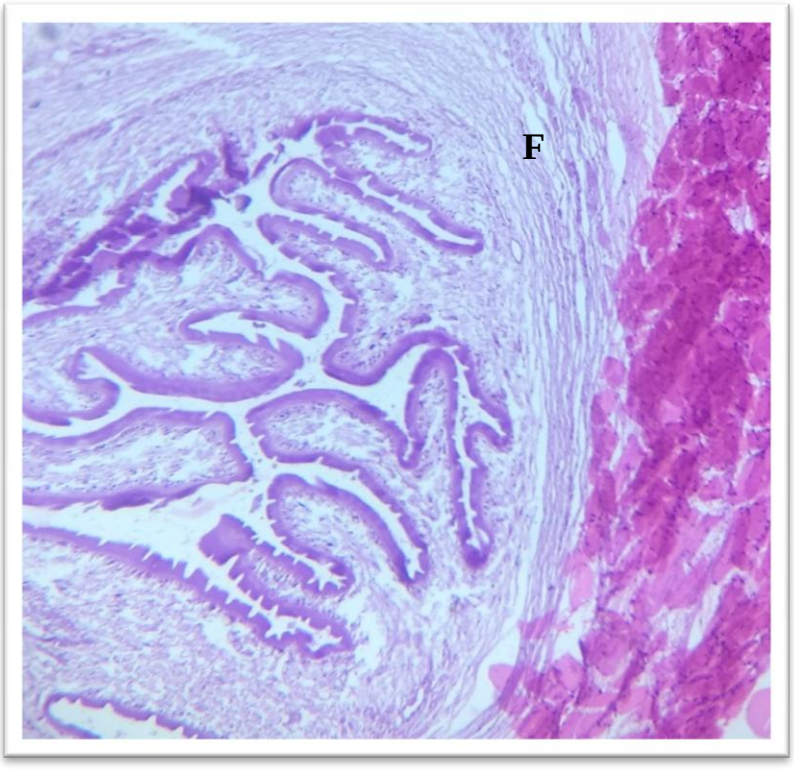


Plate 18-Tissue section stained with Haemotoxylin and Eosin stain showing fibrosis (F) at the junction of metacestode capsular layer and adjacent tissue

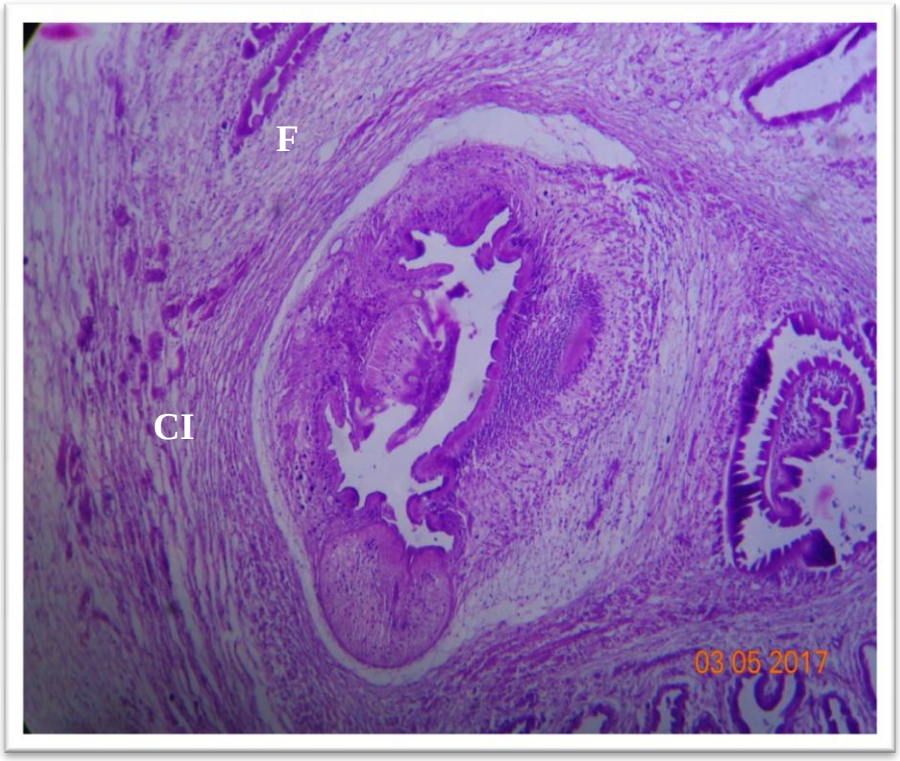


Plate 19- Fibrosis (F) and cell infiltration (CI) in and around the scolex of *Cysticercus cellulosae*

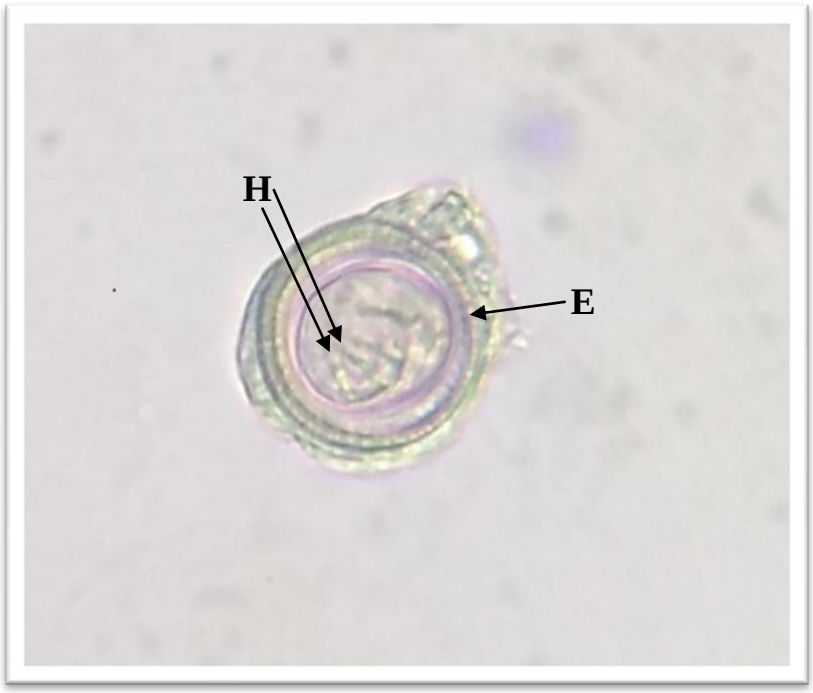


Plate 20- *Taeniid* egg showing hooklets (H) and outer striated embryophore (E)

Chapter – 5

DISCUSSION

CHAPTER - 5

DISCUSSION

Taenia solium is a zoonotic parasite which completes its lifecycle by being transmitted between humans and pigs, thus causing a serious health problem termed as cysticercosis. Cysticercosis is encountered in both humans and pigs, caused by larval stage of *Taenia solium*. At present human is the only known definitive host since the worm is known to reach maturity in intestine of humans only. Humans act as the most important multiplier, reservoir and disseminator of infection to humans and to pigs (Palowaski., 2002). Pigs act as an intermediate host and acquire the infection by consumption of embryonated eggs or gravid proglottids passed in the feces of infected primary host (human which is carrier of *Taenia solium*). In humans, racemose *cysticercus* is a predominant larval form encountered in disease (Bickerstaff *et al*., 1952) and also mainly neurocysticercosis is encountered whereas in pigs only cellulose form of cyst is encountered (Kim *et al*., 2010).

Cysticercosis has emerged as the most important zoonotic disease in the world. Approximately 50 million people are infected with the parasite and 50,000 die due to cysticercosis annually (Aubry *et al*., 1995). Cysticercosis in humans acts as health hazard by causing epilepsy and simultaneously is responsible for great monetary losses by loss of man days due to ill health of people suffering from the disease and also because of fiscal loss come upon for the treatment of people suffering from neurocysticercosis. Neurocysticercosis is responsible for 30% of epilepsy cases in endemic areas (WHO., 2017). Cysticercosis in pigs is globally responsible for huge economic losses due to condemnation of carcass. For example, annual losses due to porcine cysticercosis have been estimated to be USD 144,449 in Tanzania (Nkwengulila., 2014), 25 million euro's in 2002 in ten Western and Central African countries (Zoli *et al*., 2003), USD 5.0 million in the Eastern Cape province of South Africa in 2004 (Carabin *et al*., 2006) and USD 164 million for all of Latin America in 1991 (Murrell., 1991).

In India, cysticercosis is highly prevalent in Northern states particularly in Bihar, Orissa, Uttar Pradesh and Punjab. Saigal *et al*. (1984) in a study showed that out of 156

proven cases of cysticercosis from Patiala, 88 per cent cases presented were with Solitary lesion.

In the present study, Out of 600 pork samples examined at different meat shops in Jammu, 7 meat samples were found positive for the presence of *Cysticercus cellulosae*; with an overall prevalence of 1.16 per cent where as Chawhan *et al*. (2015) examined 519 pigs in Punjab and founded an overall prevalence of 4.23 per cent. Similarly Saravanan *et al*. (2014) conducted a study in Bareilly on porcine cysticercosis with an overall prevalence of 5.14 per cent. The prevalence recorded in Jammu was markedly less than recorded in other states throughout the country.

The probable cause of low prevalence of *Cysticercus cellulosae* in pigs is that majority of the state population is Muslims, which hold a religious taboo against the consumption of pork. As humans act as the disseminator and primary source of infection for swine so, without their involvement the disease cannot affect swine population of larger area, thus disease is of low prevalence in the studied area. Secondary reason is awareness of consequences of disease among population. The factors described above can cumulatively be responsible for low prevalence of disease in the state.

In the present study, age wise prevalence recorded was 1.04 per cent (<1yr) and 1.38 per cent (>1yr) respectively. Similar results were shown by Chawhan *et al*. (2015) with 3.8 per cent in <1 year of age group and 5 per cent in pig >1 year of age. Sharma *et al*. 2004 showed varied results with age-wise prevalence of 6.48% in younger pigs of <1year of age than those aged >1 year with a prevalence of 6.25%. On the contrary Saravanan *et al*. (2014) reported the disease to be more prevalent in young animals with 5.34 per cent and 4.82 per cent on older animals. Borkataki *et al*. (2011) showed age wise prevalence to be highest (11.41%) in the age group of 7-12 months and lowest (7.60%) in the age group 19-24 months.

The value derived by applying chi square was 0.137 which is far less than the table value (3.841; $p<0.05$) at one degree of freedom indicates that the disease distribution is independent of age. Recorded age wise prevalence was higher in female

but the association was observed to be random as per statistical analysis. In other studies also the two variables were found to be independent of each other (Sharma *et al*., 2004).

In the present study, sex wise prevalence recorded was 1.36 per cent in males and 0.85 per cent in females respectively. Sharma *et al*. (2004) showed similar result with 8.82% in males and 4.48 per cent in females. Saravanan *et al*. (2014) on the other hand showed sex wise prevalence to be more in female (5.43%) than in males (4.82%). Similarly Borkataki *et al*. (2011) reported prevalence of *Cysticercus cellulosae* infection in male and female was 9.15 and 10.39 per cent respectively.

The value derived was 0.575 is very low in comparison to the table value (3.841; $p<0.05$) at one degree of freedom represent that the disease distribution is not associated with sex of animal. In the present study, finding of statistical independency of porcine cysticercosis with respect to age and sex substantiate with the various studies carried out in world (Onah and chiejina., 1995; Sakai *et al*., 1998). The present study showed higher prevalence in males than females owing to the fact that generally more males are slaughtered than female, as female serve dual purpose which is meat production and crop production (piglets).

In Jammu, both desi and crossbreed are being reared for meat purpose. The prevalence was found to be 2.67 per cent in desi breed and 0.48 per cent in crossbred animal. Borkataki *et al*. (2011) reported high prevalence of disease in crossbred (12.53%) than in desi breed (7.49%). Sharma *et al*. (2004) Prevalence of porcine cysticercosis was relatively higher in cross bred pigs (5.88%, 6/102) than in the non-descript local breed of pigs (4.11%, 3/73).

On statistical analysis of data via application of chi square. The value derived was 4.322 which is more than table value (3.841: $p<0.05$) clearly indicating an association between disease distribution and breed of pigs. In the present study higher prevalence of cysticercosis is recorded in desi breed than crossbred. Similar finding were reported in Punjab by Sharma *et al.* (2004). The possible reason behind the observed result is that desi breed being hardy in nature (able to sustain on minimum feed and are capable of surviving effectively in harsh climatic condition of Jammu) is mainly reared

extensively whereas the crossbred animals are more prone to environmental factors (temperature, relative humidity etc) require much more care for their survival as well as to achieve their high production rate. These factors thus indicate that desi breed is being continuously exposed to the foci of infection present in environment which is probably contributing to increased prevalence of *Cysticercus cellulosae* in them.

Although, no government farm or intensive farming is being done in Jammu region but the private farms with semi-intensive management system and extensive management system provides a basic framework on the basis of which management system based prevalence can be calculated. In the present study, the prevalence for semi-intensive system was recorded was 0.50 per cent and 2.42 per cent in extensive system of management. The result is in accordance with the study Poudet *et al.* (2002).

Martinez *et al*. (1997) reported higher prevalence of disease in area where more than 50% of household had no latrines and pigs were freely allowed to scavenge outside. Vazquez *et al.* (2001) stated that restrained rearing of pig with basic hygiene maintainence and sanitary conditions may act as an effective and practical intervention in control of porcine cysticercosis in rural communities. When the data collected in the present study was subjected to statistical analysis by applying of chi square, the value derived was 5.351 which is more than the standard table value (3.841; $p<0.05$) indicating a significant positive association between the disease prevalence and management system. The study depicts that a continuous foci of infection is present in the environment which acts as a potential source of infection for extensively reared pigs due to their scavenging habits. Khaing *et al*. (2015) showed husbandry system to be factor significantly (OR=5.1; 95% CI=2.4-11.2) contributing in occurrence of porcine cysticercosis.

Season wise prevalence recorded for porcine cysticercosis was recorded highest in post monsoon period (2.36%) and lowest was recorded in winters (0.58%). The data depicted table 17 was when analyzed had value lower than the standard value (OR = 95% CI= 3.814; $p<0.05$) which clearly depicts that there is no significant association between the two variable.

The data generated through present study was in discord with the data generated in a study conducted with highest prevalence in autumn (5.10%) and lowest in winter (2.65%) by Deka *et al.* (1989). Similarly contradictory results were seen in a study conducted in Assam, which showed highest prevalence during pre monsoon (10.93%) and lowest during monsoon (7.82%) by Borkataki *et al*. (2011). Highest prevalence during post monsoon in the present study could be attributed to the fact that more pigs consumed eggs of *Taenia solium* during monsoon (as rain water can take off worm eggs along with its flow to a distant area, thus exposing more animals) take about 2-3 months for development into *Cysticercus cellulosae* in pigs leading to visible infection in Post monsoon.

In the present study, the predilection site for the presence of *Cysticercus cellulosae* in pig were thigh muscle, shoulder and muscle of neck region, where the cyst was found in all 7 positive carcasses. OIE, 2014 stated that reports of higher presence of cyst in shoulder and muscle have been recorded. None of the positive samples showed the presence of cyst in heart. Out of the 7 carcasses found positive none of the carcasses showed presence of cyst in heart. Ocular and orbital cysticercosis has been reported in pigs (Cardenas *et al*., 1984) but in the present study no cyst was found in eyes of pigs.

In the present study, microscopic examination of cyst revealed the presence of four suckers and two rows of rostellar hooks in the scolex. The rostellar hooks are the characteristic differentiating feature between *Taenia solium, Taenia saginata* and *Taenia asiatica*. The presence of rostellar hooks on the protoscoleces confirmed that the metacestode infecting the pig carcasses was of *Taenia solium*. Thus, the samples were negative both for *T.saginata and T.asiatica*. The shape of suckers was round with mean length and width recorded for suckers – 273.33 ± 12.12 µm and 228.33 ± 9.51µm. Fan *et al*. (2001a) showed similar result where the size of suckers recorded was 253µm.

In the present study, the double row of rostellar hooks consists of a row of small and large hooks arranged alternately. Number of hooks varied from cyst to cyst with a 27 per cyst. The hooks had a characteristically divided into blade, guard and handle. Mean length of hooks recorded was 154.66 ± 10.72µm and 113.33 ± 9.84µm for large and small hooks respectively. The measurement of rostellar hooks of *Taenia solium* have also

been done by Okabe. (1957) length recorded was 128-162µm and 100-130µm, Vester. (1967) recorded length of 160-170µm and 110-140µm, Soulsby. (1982) reported 140-180µm and 110-140µm for large and small hooks, respectively.

Boa *et al*. (1995) reported a mean number of hooks on the protoscoleces were 27 and the length of small and large hooks varied between 105-130µm and 168-174µm.

In the present study, the histopathological section displayed intact cyst with a bladder wall and scolex. Inside of the cysts were characterized by presence of spiral canal, hooklets and well preserved vesicular membrane. Pathological changes seen in tissue surrounding the cyst- the skeletal tissue surrounding the cyst showed lymphocytic infiltration and fibrosis in muscle connected to the core of the cyst. An interesting finding is presence of vasculitis characterized by perivascular fibrosis and congestion. Perivascular fibrosis was more pronounced in blood vessels present adjacent to cyst.

The findings were in harmony with works of Aluja and Vargas. (1988) as they also reported prominent inflammatory reaction in the parenchymatous region and in and around scolex of the parasite. Similar finding were reported on histolopathological examination of infected tissue samples by Molinari *et al*. (1983). A pronounced cellular reaction consisting mainly of lymphocytes, macrophages and a few plasma cells which is in concord with finding of Willms and Merchant. (1980) and Blazek *et al*. (1981). In the present study, cyst was in early second stage of degeneration characterized by fibrosis of outer membrane and presence of inflammatory cells along the outer covering and no granuloma formation was observed. The above finding can be attributed to the fact that most of the pigs slaughtered in the study area are generally of 8-12 months of age. As the cyst survive for several years before undergoing degenerative changes, so probably due to short period of infection (due to early slaughtering) the degenerative changes encountered were not more pronounced.

In the present study, the eggs observed were oval in shape had an outer shell with an embryophore and with embryo inside. The embryophore was thick, globular in shape and striations were present throughout the embryophore giving it a characteristic cartwheel appearance. Soulsby. (1982) showed similar microscopic appearance. The eggs

detected varied in size with each but an average size 40.4 ± 4.26µm × 28.8 ± 3.02µm were detected. The size measured was in accordance to the study conducted earlier (Laclette *et al*., 1982).

This present study, although represent data best to the knowledge of researcher may show inconsistency on repetition due to certain restriction of research itself such as - different pig rearing practices being employed and along with awareness among human population regarding mode of transmission of disease and deworming practices being followed by them, lack of cooperation of butchers in availability of pork samples positive for *Cysticercus cellulosae,* animals which may have been recently infected were not able to show cyst as the development of cyst took 2-3months, so they may have been excluded due to lack of application of serological and molecular tools for early detection of disease because of abridged time frame of study, unknown parasitological status of pigs and underreporting of disease due to its samples size.

Chapter – 6

SUMMARY AND CONCLUSIONS

CHAPTER – 6

SUMMARY AND CONCLUSIONS

Taenia solium taeniosis/cysticercosis is a zoonotic disease of great magnitude and is invariably present throughout the world. The disease, although of great importance has been neglected so far consistently, owing to the fact that the primary disease (taeniosis) does not pose dire threat to the public health. The secondary disease (cerebral cysticercosis in humans and porcine cysticercosis) is however of marked importance due to its grim manifestation in humans *viz* headache, epileptic seizures, blindness, mental retardation and death whereas in pigs clinical manifestation of disease are not of much substance but the economic consequences of disease in terms of production losses and meat condemnation, make porcine cysticercosis a disease which require immediate action for its control and eradication.

Taeniosis/cysticercosis is associated with unhygienic conditions and substandard rearing, shoddy meat inspection and control. Ingestion of *Cysticercus cellulosae* via uncooked or partially cooked pork (smoked or pickled pork) results in human tapeworm infection (taeniosis) where as intake of embryonated egg by human or porcine results in development of cysticercosis in humans as well as in porcine. So, porcine cysticercosis is meticulously related to pig husbandry along with routine hygiene and sanitation practices.

Pigs are relatively easy to maintain and are readily marketable. Also, they are the only livestock which require no rearing investment since free range pigs due to their scavenging habit are capable of finding their own feed which many times is garbage and human excreta. The infected individual passes gravid proglottids having thousands of eggs in feces and acts a source of infection for pigs. Places where proper meat inspection and control is lacking, infected pigs are often slaughtered informally and the pork is consumed by oblivious public, thus completing the lifecycle of parasite. Therefore, the control of disease in humans depends largely upon the control of disease in animals and for the latter; determination of prevalence of disease in animals is the key to strategize eradication policies. Thus, the present study was framed to quantify the presence of disease in terms of prevalence in pigs of Jammu region.

In the present study, out of 600 pigs examined at different local slaughter shops in area of Chatha, Gangyal and R.S. Pura in Jammu, 7 were found positive during the postmortem inspection showing an overall prevalence of 1.16 per cent. No variation in the prevalence was recorded with respect to age, sex and season where as prevalence was found to be significantly related to the breed and managemental practices of husbandry being followed in the study area.

A total of 124 cysticerci were recovered from infected pig carcasses and most of the cysticerci were found in thigh muscle, neck muscle and fore quarter followed by intercostal muscle. No cyst was found in eye and heart. Month wise prevalence recorded was found to be maximum in October where as very few cases were reported in summer and monsoon on meat inspection.

In morphological examination, grossly white opaque cyst was observed. On microscopic examination of recovered cyst by borax carmine staining alternate arrangement of large and small rostellar hooks was observed in maximum of cyst where as in some cyst single row of small hooks was seen. All the samples tested through morphological studies showed the cyst recovered to be of *Taenia solium*. Results thus anticipated that morphological analysis can be used as a legitimate standard for the differentiation between *Taenia solium, Taenia saginata* and *Taenia asiatica.*

Histopathologically, the tissue sections demonstrated mild inflammatory reaction both inside and surrounding the larvae. The entire cyst showed infiltration of inflammatory cells primarily lymphocytes followed by macrophages and plasma cells both in and around the larvae (cysticerci) of parasite. Slight deposition of fibrous tissue was observed around the cyst wall whereas no marked degenerative changes were observed. Perivascular fibrosis and marked vasculitis along with congestion of blood vessels were reported. Cysts of various sizes were observed in different parts of body and morphology of all developed cyst were similar irrespective of organ of their recovery.

In the present study, out of 25 feed samples of pigs screened, a single sample was observed to be positive for *Taeniid* egg. The egg observed on morphological examination showed an outer brown striated embryophore with an embryo inside. The embryo had six

hooklets, thus the recovered eggs was characteristically similar with the eggs of *Taeniid* family. The size recorded by micrometry showed that eggs recovered were comparatively larger in size than recorded by various previous examinations. The present study indicated that on the basis of gross morphological examination only the differentiation between different species of *Taenia* genera cannot be done.

Conclusion

The present study concludes the following points:

1. The prevalence of porcine cysticercosis was recorded to be 1.16 per cent and was recorded higher in pigs reared in free range conditions in comparison to pigs which were stall fed.

2. Histopathological examination showed marked changes in musculature of infected pigs. Thus concluding that the parasite is capable of manifesting disease in them.

3. The study indicated that the contamination of feed is not the major root cause of infection of *Taenia solium* for pigs.

The study concludes that porcine cysticercosis is present in Jammu and the pig population of study area is playing an efficient role in maintaining the infection of *Taenia solium* in Jammu. However, the prevalence recorded in study area is markedly lower in comparison to prevalence recorded by various researchers in other states of India, thus signifying that the disease can be eradicated in the studied area, if proper control measures are applied. Few suggestions for control and eradication of porcine cysticercosis in Jammu are: stringent meat inspection, avoiding open defecation, proper de-worming in animals as well as humans, generating awareness among population regarding mode of transmission of disease (pork infected with *Cysticercus cellulosae* as a source of infection for taeniosis and food stuff contaminated with for cysticercosis) and the consequences of it, making the public aware regarding the importance of hand washing after defecation in preventing cysticercosis etc.

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CERTIFICATE – IV

Certified that all the necessary corrections as suggested by the external examiner/ evaluator and the advisory committee have been duly incorporated in the thesis entitled "**Epidemiological Study of Prevalence of *Cysticercus Cellulosae* in Pigs of Jammu Region**" submitted by **Miss. Rashmi Sharma,** Registration No: **J-15-MV-429.**

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