CURRENT STATUS OF FOOD-BORNE PARASITIC ZOONOSES IN INDIA

BB Bhatia

College of Veterinary Sciences, GB Pant University of Agriculture and Technology, Pantnagar-263145, UP, India.

Abstract. Food-borne parasitic zoonoses have a major impact on the health and economy in developing countries in the tropics and sub-tropics. Complex socio-economic and socio-cultural factors impact on the maintenance of parasitic zoonoses. In addition to human disease, some of these parasites are responsible for economic loss to livestock production.

Throughout India, problems of food-borne parasitic zoonoses differ because of varied food habits. Other factors, however, such as unhygienic living conditions, lack of education, poor personal hygiene, poverty and occupation, also contribute to the dissemination of parasitic infections. The present status of various food-borne parasitic zoonoses are briefly given here.

MEAT-BORNE PARASITIC ZOONOSES

Sarcocystis suihominis

Although the occurrence of microcysts of *Sarcocystis* in the musculature of pigs in India has been known, only recently were microcysts of *S. suihominis* identified and differentiated from species of *S. miescheriana* in striated muscles of different organs of pigs in India (Solanki *et al,* 1990). In both cases, the prevalence of *S. suihominis* had been found surprisingly higher (47.11%) than *S. miescheriana* (43.14%).

Pigs raised in rural areas are generally fed on garbage and human refuge, including night soil. The coprophagic nature of pigs exposes them to infective materials of all kinds. These animals are slaughtered in unhygienic places without official supervision. The offal are carelessly discarded. Half-roasted pork is considered a delicacy in some communities, particularly on the occasion of a ceremony. *S. suihominis,* more than *S. hominis* (which has a cattle-man cycle), causes severe digestive troubles in humans. The preponderance of this species in an undescribed breed of pigs (> 80 per cent of the total population of pigs in India) needs detailed investigation. The continuous propagation of *S. suihominis* in nature proves of human infection which has yet to be searched and confirmed especially in persons handling pigs and consuming pork.

Sarcocystis hominis

There is only one report on the occurrence of this species in muscles of cattle in Madhya Pradesh (Jain and Shah, 1987).

Toxoplasma gondii

Antibodies to *T. gondii* have been demonstrated in 9.7 to 33.7 percent cases of sheep, goats, pigs, cattle, buffaloes, camels, horses, cat and dogs (Chhabra *et al,* 1985). Dubey (1987) stated that isolation of *T. gondii* from pig and sheep is very low and clinical toxoplasmosis is not known in animals in India. A few cases of abortions were, however, seen in goats with titers of 1:64 or above (IHA titers) and a neonatal mortality was seen in goat born to dams with titers from 1:8 to 1:256 from Parbhani (Marathwada) (Singh and Msolla, 1986).

In humans, significant levels of toxoplasma antibodies have been shown through indirect hemagglutination, ELISA and dye tests (Gupta *et al,* 1985). Seropositivity has been demonstrated both in the vegetarian and non-vegetarian popula-

tion. Parasitologically proved cases of human *Toxoplasma* infections have been documented (Parija, 1990).

In India, transmission of *T. gondii* to humans by ingestion of meat from pigs, cats and chicken, seems to be minimal because these meats are well-cooked before consumption. Transmission of *T. gondii* through oocysts shed by infected cats appears to be a more viable source of *Toxoplasma* infection for humans and animals in India (Dubey, 1987). However, systematic studies of toxoplasmosis in animals and man are needed to determine its status in India.

Trichinella spiralis

There were a few reports of the occurrence of *T. spiralis* in some mammalian hosts, namely, from a civet cat in Calcutta (West Bengal) (Schad and Chowdhury, 1967); a *Bandicota bengalensis* in Bombay (Niphadkar, 1973); and in 3 of 500 domestic pigs examined in Bombay (Niphadkar *et al*, 1979). Trichinosis has not been reported in humans in India.

TAENIASIS/CYSTICERCOSIS

Taeniasis is a zooanthroponosis in which man is an essential definitive host whereas cattle and pig act as intermediate host for *Taenia saginata* and *T. solium*, respectively. Transmission from man to animals occurs by handling calves and piglets, contamination of feed and water with *Taenia* eggs. Transmission may also occur through the coprophigic activity of pigs on human night soil. Transmission from animal to man depends on ethnological factors, ie, food processing and food preferences. In India, taeniasis is most common among castes in India that consume half-baked or smoked meat, and where the slaughter of animals is unsupervised.

Taenia saginata/Cysticercus bovis

In India, the occurrence of *T. saginata* in man, and its metacestode, *Cysticercus bovis*, in muscles of cattle is rare. Recently, there have been a few case reports of *C. bovis*: 8 bullocks and 9 buffaloes in western Uttar Pradesh (Gaur, 1976); one bullock in Andhra Pradesh (Sreemannarayana and Christopher, 1977), and a Gir cow in Madhya Pradesh (Kolte *et al*, 1981).

Taenia saginata and *T. solium* have been observed in Sikkim with higher infection rates in Tibetan, Lepchas, and Sikkimese Bhotiya communities, than in Nepalis and Indians (Mitra, 1970). Eight cases of human *T. saginata* infection also included a Hindu (Anantaraman, 1984). Lall (1985) reported *T. saginata* in 0.1 percent people in Andaman and Nicobar Islands. Ahmad *et al* (1988) found *T. saginata* infection in 1.5 percent of the rural people in Kashmir. Information on the present status of *T. saginata* in India is very limited; research is needed, especially since there is no complete ban on the slaughter of cattle in some States of the country.

Taenia solium/Cysticercus cellulosae

The prevalence of the metacestode of *T. solium, C. cellulosae,* in muscles of pigs is very well established in different parts of India, with an overall prevalence ranging from 2.0 to 28.8 percent. Based on the work conducted since 1980, the prevalence has been detected as high as 15.5 percent in pigs in some northern parts of the country. The cysticerci are commonly found in muscles of the thigh, tongue, and neck, and sometimes in the liver, heart, lungs, lymph nodes, and brain (Deka and Gaur, 1990). The prevalence rate of *T. solium* in man varies from 0.75 to 1.00 percent in certain communities, particularly in rural areas where there is more contact with pig populations (Verma and Ahluwalia, 1981; Pathak *et al*, 1984).

Cysticercosis in humans is caused by the invasion of *T. solium* eggs, leading to a variety of neuro-ocular and cerebral conditions depending of their localization. Human infection occurs most probably through food or drinking water contaminated with human feces containing *T. solium* eggs. Unwashed raw vegetables, grown in soil irrigated by sewage water, may be the other source of infection.

Recent reports on human cysticercosis in India include the fatal case of a 51 year-old man from Delhi with symptoms of headache, dimness of vision, vomiting and convulsions (Vijayan *et al*, 1976); a free-floating cysticercus found in the anterior chamber of the eye of a 14 year-old boy and three other cases of ocular cysticercosis from Pondicherry (Kapoor *et al*, 1977; Kapoor, 1978); 20 cases of neurocysticercosis of encephalitic type reported from Bangalore (Karnataka) (Srinivas *et al*, 1980); a 14 year-old Hindu boy from Ambala

having a painless cyst in the outer part of the upper eyelid (Singh and Kaur, 1982); a case of acute suppurative dacryoadenitis (a palpable lobe of the lachrymal gland) from Delhi (Sen, 1982): a strict vegetarian 8 year-old girl in Madurai with signs of raised intracranial pressure (Inpasekaran *et al,* 1983); and a 22 year-old woman from Aligarh (UP) with a nodule on her back (Khan *et al,* 1984). Recently, there was a report from Bangalore of a 15 percent prevalence rate on neurocysticercosis (Chandramukhi *et al,* 1988).

These reports clearly indicate a well established infection with *T. solium* in human and pig populations in India, and that the spread of infection between the two hosts is mainly due to a lack of inadequate sanitation for humans and a neglected type of management of pigs, especially in rural areas.

FISH-BORNE PARASITIC ZOONOSES

Gnathostoma spinigerum

There have been reports of *G. spinigerum* in a cat from Madras (Tamil Nadu) (Chellappa, 1978), in dogs from Kerala (Nayar *et al,* 1978), and recently in 1.65 percent of the dogs from Assam (Baruah and Gogoi, 1988; Gogoi and Baruah, 1988). Infective larvae of *G. spinigerum* were also found in viscera and muscles of 3.09 percent of fish *(Ophiocephalus punctatus).* A common water-flea *(Mesocyclops leukarti)* was identified as the first intermediate host in which second stage larvae develop in two days (Gogoi and Baruah, 1988). There has not been a report of human gnathostomiasis from fish since a worm was reported from subcutaneous tissue of a man from West Bengal (Mukerjee and Bhaduri, 1945). Other fresh water fish, such ad *Ophiocephalus striatus, O. argus,* and *Clarias batrachus,* have also been found to harbor infective larvae of *G. spinigerum* (Rai, 1976).

Spirometra sp.

Saleques *et al* (1990) reported *Spirometra* tapeworms in a cat fed offals of fish bought at a market in Pantnagar (UP), and he reviewed two earlier reports from Calcutta and Jabalpur (MP). A mongrel dog was also reported with a spirometrid tapeworm (Pal *et al,* 1981). A case of human sparganosis, possibly due to the ingestion of *Cyclops* containing procercoids, was reported from Jodhpur (Rajasthan) (Datta *et al,* 1982). There are no reports of transmission from carnivores to man of certain trematodes, such as *Heterophyes, Echinochasmus perfoliatus, Opisthorchis tenuicollis,* and *Pseudamphistomum truncatum,* which have infective metacercariae in edible fishes, even though these parasites are commonly found throughout India.

SNAIL- AND CRUSTACEAN-BORNE PARASITIC ZOONOSES

Angiostrongylus cantonensis

Angiostongyliasis occurs in lungs of rats in India. Two human cases were reported from Bombay (Maharasthra) with symptoms of eosinophilic meningitis; it was confirmed that raw slugs *(Laevicaulus alta)* infected with *A. cantonensis* worms were ingested (Sharma *et al,* 1981). Slugs (harboring as many as 200 larvae per gram of tissue) and a snail, *Macrochlamys indica,* were identified as intermediate hosts.

Paragonimus westermani

Paragonimiasis was reported from Manipur in 39 people (11-30 years of age) with symptoms of recurrent hemoptysis. They had eaten raw crabs *(Potaman dehani)* infected with *Paragonimus westermani* (Singh *et al,* 1986). There are a few reports of *P. westermani* in tigers *(Panthra tigris)* in India, including the latest one from the National Kanha Park, Mandla (MP) (Parihar and Srivastava, 1988).

Dracunculus medinensis

Guinea worm infection in humans is widespread in India. At least seven states in the country have endemic foci; these are Rajasthan, Maharashtra, Madras, Andhra Pradesh, Karnataka, Gujrat, Orissa besides Nicobar Islands (Kumar, 1983). Nearly 0.5 percent of those who suffer from Guinea worm infections are permanently crippled. There are more infections in remote rural areas, where nearly 5 percent of some village populations are reported to suffer from this infection. In 90 percent of the cases, the worms emerge from the lower extremities.

Human infections increase in endemic areas during the summer months when there is an acute

shortage of potable water. People draw water from step-wells and storage tanks which are often infested with *Cyclops (Mesocyclops leukarti)*. Infected persons in remote villages usually do not visit health centers for treatment; therefore, efforts of control the infection have failed in rural areas. Stray dogs are the principal reservoir hosts. Non-human primates, carnivores, cattle and horse are also reservoirs.

A Guinea worm control and eradication program was initiated in India in 1979, which included educating the people and providing potable clean water in endemic areas. There was a mass treatment program for infected humans, and biological control of *Cyclops* by introducing larvivorous fish, such as *Gambusia affinis* and *Poecilia reticulata* (Prakash and Srivastava, 1989), and using larvicidal drugs, such as Abate (Cynamid).

POTABLE WATER AND MILK-BORNE PARASITIC ZOONOSES

Cryptosporidium sp.

There have been no reports of *Cryptosporidium* infections in cattle or buffalo calves or any other farm animals in India. Human cases have been reported, however, with symptoms of diarrhea, particularly in bottle-fed children, from Vellore (13 percent) (Mathan *et al,* 1985), Calcutta (Das *et al,* 1987), Varanasi (Singh *et al,* 1988), Bombay (Saraswathi *et al,* 1988), Kashmir (Navash and Wattal, 1988) and from Chandigarh (Malla *et al,* 1987; Mahajan *et al,* 1988; Malla *et al,* 1989). There have been other reports from Bangalore and Madurai (Parija, 1990).

The widespread incidence of cryptosporidiosis in humans suggests that infections with *Cryptosporidium* in dairy animals and their calves needs investigation.

Toxocara vitulorum

Infection with *T. vitulorum* has been reported in buffalo calves (Warren, 1971). Larvae have been detected in colostrum and milk of buffaloes just after calving (Chauhan *et al,* 1974a; Gautam *et al,* 1976; Banerjee *et al,* 1983); and in organs and tissues of poultry (Chauhan *et al,* 1974b). In some communities colostrum and raw milk from buffaloes is given to children; however no cases of visceral larva migrans have been reported in India.

RAW VEGETABLES

Fasciolopsis buski

This fluke, commonly found in pigs in different parts of the country including Assam, Biharj Uttar Pradesh, Madhya Pradesh and Tamil Nadu, has been reported in 60 percent of some undescribed pig populations.

In Assam, 33 percent of pigs were found infected with *F. buski* (Sarma and Gogoi, 1986). Metacercariae adhere to the shell of water chestnuts *(Trapa natans)* which propagate in seasonal ponds and storage tanks in rural areas. This water is frequently contaminated with feces from infected pigs. Although there have been no recent reports of human infections, transmission of *F. buski* occurs when people peel the water chestnuts with their teeth.

Gastrodiscoides hominis

The infection with this amphistome fluke in caecum of pigs in India is widespread; however there have been no reports of human infections.

Other food-borne parasitic infections, such as amebiasis, giardiasis, balantidiasis, hymenolepiasis, and ascariasis are quite common in humans all over the country. Modes of transmission vary, but the most common ones are ingestion of food and water contaminated with feces from infected humans or animals and the consumption of raw leafy green vegetables irrigated with sewage water (Bhatia *et al,* 1978).

CONCLUSION

Cysticercosis, taeniasis and dracunculosis are the most common and well established food-borne parasitic zoonoses adversely affecting human health in India. Toxoplasmosis, sarcocystosis and cryptosporidiosis are emerging as important food-transmitted parasitic zoonoses pathogenic to farm animals and humans. The role of pigs seems to be important in the maintenance and

propagation of most food-borne parasitic zoonoses in India.

Although sufficient cooking of meat, fish and vegetables is generally practiced throughout the country, unhygienic living conditions, poverty and lack of education are major factors in the transmission of food-borne parasitoses in India.

REFERENCES

Ahmed M, Zutshi ML, Ahmad Shah SN. Intestinal parasites in Kashmiris (Rural study). *Indian J Parasitol* 1988; 12 : 41-4.

Anantaraman M. Animal parasitic infections of public health importance. Summer Institute, Tirupati (India), 1984; 107.

Banerjee DP, Barman Roy AK, Sanyal PK. Public health significance of *Neoascaris vitulorum* larvae in buffalo milk samples. *J Parasitol* 1983; 69 : 1124.

Baruah N, Gogoi AR. Incidence of helminths in local dogs of greater Guwahati in Assam. Abstr. *No. C-5*, III Nat Congr Vet Parasitol, Nov, 1988, Tirupati, India.

Bhatia BB, Katara PP, Agrawal RD, Ahluwalia SS. Vegetables - an important source of parasitic infections to human beings. *Vet Res Bull* 1978; 1 : 77-9.

Chandramukhi A, Muralidhar K, Katti BV, *et al.* Neurocysticercosis - a zoonotic disease and its morbidity on man. Second National Congress on Veterinary Parasitology, Bangalore (India) March, 1988 (from NIMHNS, Bangalore, India).

Chauhan PPS, Agrawal RD, Ahluwalia SS. A note on the presence of *Strongyloides papillosus* and *Neoascaris vitulorum* larvae in the milk of buffaloes. *Curr Sci* 1974a; 43 : 486-7.

Chauhan PPS, Bhatia BB, Arora GS, Agrawal RP. Migratory behaviour of *Neoascaris vitulorum* larvae in albino rat and chicken - A histologic study. *Indian J Anim Sci* 1974b; 44 : 801-4.

Chellappa DJ. An interesting observations of *Gnathostoma spinigerum* infestation in a domestic cat. *Curr Sci* 1978; 47 : 828-9.

Chhabra MB, Gupta SL, Gautum OP. *Toxoplasma* seroprevalence in animals in Northern India. *Int J Zoon* 1985; 12 : 136-42.

Das P, Pal S, Dutta D, Bhattacharya MK, Pal SC. Cryptosporidiosis in Bengal children with acute diarrhoea. *Trans R Soc Trop Med Hyg* 1987; 81 : 241.

Datta KK, Datta SP, Sharma RS, Goyal SL. Sparganosis. *J Indian Med Assoc* 1982; 79 : 78-80.

Deka DK, Gaur SNS. *Taenia solium* cysticercosis in pigs in western parts of Uttar Pradesh. *J Vet Parasitol* 1990; 4 : (In press).

Dubey JP. Toxoplasmosis in domestic animals in India. Present and future. *J Vet Parasitol* 1987; 1 : 13-8.

Gaur SNS. Prevalence of *Cysticercus bovis* in cattle and buffaloes. *Indian J Anim Res* 1976; 10 : 47-8.

Gautam OP, Malik PD, Singh DK. *Neoascaris vitulorum* larvae in the colostrum/milk of buffalos. *Curr Sci* 1976; 45 : 350-1.

Gogoi AR, Baruah N. *Gnathostoma spinigerum*, a pathogenic zoonotic nematode and the role of fish in its life-cycle in Assam. II National Congress Veterinary Parasitology, March, 1988, Bangalore (India).

Gupta SL, Chhabra MB, Gautam OP. *Toxoplasma* prevalence and human occupational groups. *Int J Zoon* 1985; 12 : 143-6.

Inpasekaran V, Kumar NA, Natarajan M. Intrafourth ventricular cysticercosis. *J Indian Med Assoc* 1983; 83 : 356-7.

Jain PC, Shah HL. *Sarcocystis hominis* in cattle in Madhya Pradesh and its public health importance. *Indian Vet J* 1987; 64 : 650-4.

Khan N, Khan AA, Ansari N. A nodule on the back - *Cysticercus cellulosae* cyst (a case report). *Indian J Dermatol* 1984; 29 : 33-5.

Kapoor S. Ocular cysticercosis in India. *Trop Geogr Med* 1978; 30 : 253-6.

Kapoor S, Sood GC, Aurora AL, Sood M. Ocular cysticercosis. Report of a free floating cysticercus in anterior chamber. *Acta Opthalmol* 1977; 55: 927-30.

Kolte GN, Vegad JL, Awadhiya RP. Note on an unusual case of cysticercosis *(Cysticercus bovis)* in a Gir cow. *Indian J Anim Sci* 1981; 51 : 370-2.

Kumar S. Guinea worm eradication programme (GWEP) V. Nat. Congr. Parasitol. Tirupati (India), June 1983.

Lall R. Intestinal parasitic infections in a section of Port Blair, Andman and Nicobar Islands. *J Comm Dis* 1985; 17 : 249-50.

Mahajan RC, Ganguly NK, Sehgal R, Malla N. Parasitic diarrhoea. *Indian J Pediatr* 1988; 55 : 829.

Malla N, Sehgal R, Ganguly NK, Mahajan RC. Cryptosporidiosis in children in Chandigarh. *Indian J*

Med Res 1987; 86 : 722-5.

Malla N, Sehgal R, Ganguly NK, Mahajan RC. Cryptosporidiosis the Indian scene. *Indian J Pediatr* 1989; 56 : 6.

Mathan MM, Venkatesan S, Geerge R, Mathew M, Mathan VI. *Cryptosporidium* and diarrhoea in southern Indian children. *Lancet* 1985; 2 : 1172.

Mitra SK. The occurrence and distribution of intestinal parasites in Sikkim. *Indian J Med Res* 1970; 58 : 796-801.

Mukerji AK, Bhaduri NV. *Gnathostoma* infection of the eye. *Indian Med Gaz* 1945; 80 : 126-8.

Navash HW, Wattal C. Cryptosporidiosis in Kashmir. *Trans R Soc Trop Med Hyg* 1988; 82 : 499.

Nayar KNM, Goerge, Kutty PT, Jalaluddin AM, Philip PJ. Gnathostomiasis in a dog — a case report. *Kerala J Vet Sci* 1978; 9 : 35-7.

Niphadkar SM. *Trichinella spiralis* (Owen, 1833) in Bandicota bengalensis (Gray) in Bombay. *Curr Sci* 1973; 42 : 135-6.

Niphadkar SM, Pradhan MH, Deshpande VS. Rediscovery of *Trichinella spiralis* (Owen, 1835) in domestic pigs in India. *Curr Sci* 1979; 48 : 372-3.

Pal MG, Chakrabarti Pramanik AK, Pradhan KK, Chatterji A. Spirometrid tapeworm in a mongrel dog. *Indian J Anim Health* 1981; 20 : 71-2.

Perihar NS, Srivastava SN. Bronchial hyperplasia in a tiger *(Panthera tigris)*. *Indian J Anim Sci* 1988; 58 : 230-3.

Parija SC. Review of Parasitic Zoonoses. AITBS Publishers Distributors, Delhi-51, 1990.

Pathak KML, Gaur SNS, Kumar D. The epidemiology of strobillar and cystic phase of *Taenia solium* in certain parts of Uttar Pradesh (India). *Indian Vet Med J* 1984; 4 : 17-8.

Prakash D, Srivastava RC. Predation efficacy of larvivorous fish on *Cyclops* transmitting dracunculosis. *Acta Hydroclin Hydrobiol* 1989; 17 : 179-88.

Rai P. 1976. Fish borne zoonoses with special reference to helminthic diseases. UP *Vet J* 1976; 4 : 52-4.

Saleque A, Juyal PD, Bhatia BB. *Spirometra* sp. in a domestic cat in India. *Vet Parasitol* 1990; 35 : 273-6.

Saraswathi K, Pandit DV, Deodhar LP, Bichile LS. Prevalence of cryptosporidia in patients with diarrhoea in Bombay. *Indian J Med Res* 1988; 87 : 221.

Sarma BND, Gogoi AR. Studies on helminths and histopathology of some common trematodes of local pigs in Assam. *Indian Vet J* 1986; 63 : 366-70.

Schad GA, Chowdhury AN. *Trichinella spiralis* in India. Rediscovery in Calcutta and the ecology of its maintenance in nature. *Trans R Soc Trop Med Hyg* 1967; 61 : 244-8.

Sen DK. Acute suppurative decryoadentitis caused by a *Cysticercus cellulosae*. *J Pediatr Opthal Strabismus* 1982; 19 (2) : 100-2.

Sharma KD, Renapurkar DM, Bhoopale MK. Study of a focus of *Angiostrongylus cantonensis* in Greater Bombay. *Bull Haffkine Institute* 1981; 9 : 38-46.

Singh B, Msolla P. Seroprevalence and pathogenesis of *Toxoplasma gondii* in sheep and goats in tropical regions. *Bull Anim Health Prod Afr* 1986; 34 : 236-40.

Singh BK, Gulati AK, Prasad KN, Singla PN. *Cryptosporidium* infection in children with acute diarrhoea. *J Commun Dis* 1988; 20 : 136.

Singh G, Kaur J. Cysticercosis of the eyelids. *Ann Opthal* 1982; 14 : 947-50.

Singh TA, Mutum SS, RAzaque MA. Pulmonary paragonimiasis. Clinical feature, diagnosis and treatment of 39 cases in Manipur. *Trans R Soc Trop Med Hyg* 1986; 80 : 967-71.

Solanki PK, Shrivastava HOP, Shah HL. On morphology of sarcocysts of *Sarcocystis miescheriana* and *S. suihominis* recovered from naturally infected domestic pigs. *Indian J Anim Sci* 1990; (In press).

Sreemannarayana O, Christopher KJ. 1977. A case of combined infection of cysticercosis and sarcosporidiosis in bullock. *Indian J Anim Health* 1977; 16 : 188.

Srinivas HV, Vasudev-Rao T, Deshpande DH. Cerebral cysticercosis: Clinical and pathological observations with emphasis on the encephalitic type. *Clin Neurol Neurosurg* 1980; 82 : 187-97.

Verma TK, Ahluwalia SS. Potential danger of cysticercosis of taeniasis in man and animals. *Livestock Advisor* 1981; 6 : 54-6.

Vijayan GP, Biswas H, Arora RR, Saluja GS, Mathur KK. A fatal case of *Cysticercus cellulosae* infection in man. *J Commun Dis* 1976; 8 : 334-6.

Warren EG. Observations on the migration and development of *Toxocara vitulorum* in natural and experimental host. *Int J Parasitol* 1971; 1 : 85-99.