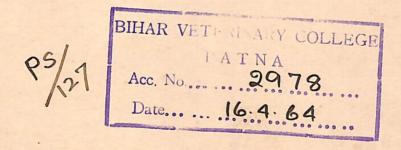


Studies on Helminth and Protozoan Parasites of Domestic Pig (Sus scrofa domestica)

Birendra Kumar Sinha



PARASITES OF DOMESTIC PIGS (Sus scrofa domestica).

THESIS

State San Share that Balance Shares

Submitted to the University of Magadh in the Faculty of Veterinary Science in partial fulfilment of the requirement for the award of Master of Science (Veterinary) Degree.

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Certified that the work described in this
Thesis entitled "STUDIES ON HELMINTH & PROTOZOAN
PARASITES OF DOMESTIC PIGS (Sus scrofa domestica)
is the bonafide work of BIRENDRA KUMAR SINHA, carried out under my guidance and supervision.

an Var 23.10.63

(A. K. VARMA)

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ABSTRACT

Title - Studies on helminth and protozoan parasites of Domestic pigs (Sus scrofa domestica)

This thesis deals with the helminth and protozoan parasites collected from 150 Deshi Domestic pigs in the Gangetic plains at Patna and 4 Yorkshire pigs at Gauriakarma (Hazaribagh). The pigs were examined postmortem and helminths were collected. Faecal samples from rectum were examined for protozoa. These parasites were morphologically studied. Their taxonomic status is discussed.

Eighteen species of helminths, B.coli and Coccidia were encountered. All of them except Gastro-discoides hominis var.suis and Fasciolopsis buski are reported from Bihar for the first time. The incidence of infection with these parasites has been worked out including the percentage of multiple infection.

Pathology of natural infections/F.buski,

Opisthorchis noverca, Ascaris lumbricoides var. suum

(in liver), Simondsia paradoxa, Metastrongylus apri,
and stephanurus dentatus has been studied. The gross
and histopathology are described. The pathology of

O.noverca in the pancreas of pigs is described for the

first time.

Faecal samples of 436 pigs from two distinct physiographic and climatic zones of Bihar were examined.

The incidence of infection with different helminths and protozoa in these two regions has been worked out. Marked higher incidence of <u>Trichuris</u> sp. and <u>Metastrongvlus</u> sp. has been found at Gauriakarma situated on southern plateau of Bihar.

Development and pathogenicity of A.lumbricoides
var. Suum have been studied after exposure to experimental
infection in white rats, guineapigs, rabbits, sheep, goats
and pigs. Observations have been made on larval migration
and their further development in the intestine. The
pathogenic effects have been assessed by observing
clinical symptoms and by studying the gross and histopathologic changes in the liver and lungs of animals
sacrificed on the 5th and 10th day. Haematology was
studied only in lambs and kids.

Biology of S.dentatus, the most commonly encountered parasite in this State, was studied. Hatching time, larval development and their relative survival have been observed at room temperature and at a constant temperature of 27°C.

Two local annelids Entypheus waltoni and exposedto

Pheretima sp. were/infective third stage larvae. E.waltoni examined from 1 to 40 days after infection harboured a large number of larvae in their gut, but Cheretima took lighter infection.

Guineapigs and rabbits were also exposed to infective third stage larvae to observe the further development.

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INTRODUCTION

The antiquity of pig domestication in India dates back to the pre-historic civilization of Mohenjo-daro with evidences of Indus people consuming pork as food (Tripathi, 1960). Even during later Vedic and Pauranic period swine has figured in mythology and religion and has continued to be the only cheapest source of animal protein to the millions of people in India, particularly those hailing from lower social and economic strata.

In other advanced countries with better breeding and husbandry practices porcine is regarded as one of the most useful and valuable domestic animals by virtue of its high prolificacy, scavenging habits, efficiency with which it converts feeds into edible meat and special capacity to utilise food that might otherwise be wasted. Pork is higher in energy content than other meat (Morrison, 1958) and the pig is said to increase one pound in live-weight for every 3.5 lbs. of food consumed.

On economic evaluation pig excels all other domestic animals. There is no waste matter

in the pig industry. The flesh is consumed as human food, so is the part of the offals. The non-edible offals can be utilised for the production of fat, animal food and fertilisers. Even skin and rind are eaten. Bristles alone feed a separate industry for making brushes of all sorts. Several medicinal agents and enzymes are prepared from endocrine and other glands.

Such an important, useful and paying industry has received only scant attention in India. Pigs are maintained mostly in villages and suburbs of towns on most unscientific lines with resultant poor out-put. According to 1951 census pig population of India was 4,420,000 with estimated pork production of 23,633.2 tons a year (Whyte, 1956) yielding 0.535 ton per 100 pigs a year. Although the latest figures are not available, the overall picture and economics of this industry may not be very much encouraging.

Efforts are being made to popularise the pig industry in India with the application of modern scientific and technological methods. But the losses, the industry is incurring and would incur due to several bacterial, viral, nutritional and parasitic diseases, need hardly be overemphasized. Of these, parasitic diseases call for special attention, as

they hit the swine population very hard. Pigs by virtue of their close feeding to the ground and scavenging habits, are more vulnerable to picking up such infections.

Besides the losses due to gross parasitism, greater losses come from the characteristic insiduous nature of the parasitic infections, as they do not necessarily kill the animals but debilitate of maim them, thereby increasing the cost of production on the one hand and depreciating their marketable value on the other, putting aside the condemnation of several edible parts due to parasitic damages.

The economic losses can well be imagined from an example in U.S.A., where losses due to Stephanurus dentatus and Ascaris infections only have been estimated to the tune of 72 million (Andrews and Tromba, 1956) and 52 million (Spindler, 1956) dollars respectively.

Parasitism in pigs presents another important aspect. The occurrence of several parasites of zoonotic importance has got great epidemiological significance which is inherent in close association between human and swine population. It acts as reservoir host, polluting the human surroundings

and disseminating the infective materials. Some of the parasitic larval phases are known to migrate in the body of certain domestic animals telling upon their health and productivity.

even the basic informations on seasonal and regional incidences, ecology, biology, pathology and other implications of various parasites affecting swine population in this country are very meagre which make their effective control difficult and these parasites continue to play their serious role on the economics of pig industry in this country and to foster a potential danger to the human population •

In Bihar State, which has an increasing pig population of 8,67,961 according to 1961 census against 6,84,638 of 1956, practically no work has been done on parasites of domestic pigs, except that reported by Varma (1954) on <u>Gastrodiscoides hominis</u> var. suis and <u>Fasciolopsis huski</u>.

The State of Bihar lying between latitudes 21°58' N - 27°31' N and longitudes 83°20' E- 88°32' E has an area of 67164 square miles with two distinct topographic divisions and typically monsoon climate. The Southern high land of Chhotanagpur, with an

average altitude of 1000 to 2000 ft. above sea level

has an undulated topography, thin surface soil on rocky stratum, thick natural vegitation and practically no water logging area. Rainfall (50°-60° and above) and humidity are comparatively higher. The Gangetic plain with an average altitude of 100 to 200 ft., has mostly cultivable land irrigated by network of perennial rivers. The vegitation is thin and several water logging areas are present. The rainfall is comperatively low (40-45°).

The present study was undertaken to determine the incidence of different helminth and protozoan parasites occurring in swine in these two distinct physiographic and climatic zones of this State and also to find out whether there exists any difference in their geographical distribution.

In view of heavy losses occasioned
by the pig due to Stephanurus dentatus and
Ascaris lumbricoides var. suum, studies were
also made on some aspects of their biology and
pathology. The migratory behavious of Ascaris
lumbricoides var. suum, their development to
the adult stage and associated pathology in
local breeds of sheep, goats, certain laboratory

animals and pigs were studied. Also, observations on the bionomics of the larval stages of Stephanurus dentatus, its infection and persistence in two local species of earthworms and infection to certain laboratory animals were made. These are reported in Chapters II & III respectively.

CHAPIER I.

PARASITES IN DOMESTIC PIGS
IN BIHAR.

Baylis and Daubney (1922 & 1923) reporting on the parasitic collection of Zoological Survey of India records Ascaris lumbricoides, Trichuris trichura from wild boar (Sus cristatus), Stephanurus dentatus and Metastrongylus apri. In the latter two cases it was uncertain whether they were of Indian origin (Baylis, 1936) .

Maplestone (1930) described a number of nematodes

from 49 pigs examined at Calcutta. The trematodes, Fasciolopsis

buski, Paryphostomum sufrartyfex (33%), Opisthorchis noverca var. lobata (5%), Opisthorchis noverca var. orbiculata (5%) and Gastrodiscoides hominis (55%) collected by him were described by Bhalerao (1931). Later Rao and Ayyar (1933) recovered 5 pairs of schistosomes from 5 pigs out of 81 examined at Madras. They described the morphology in detail and proposed new species Schistosoma suis taking Schistosoma incognitum Chandler, 1926 as its synonym. But, later in accordance with the law of priority in zoological nomenclature Srivastava & Sinha (1956), while redescribing the morphology of this parasite have maintained S. incomitum Chandler, 1926 as the valid name of the species with S. suis Rac & Ayyar, 1933 as its synonym.

Bhalerao (1935) and Baylis (1936 & 1939) in their works have compiled all the upto-date records of

parasites from Indian pigs with brief description of all the species.

Morrison (1936) reported cysticercosis in both native and imported pigs to be common in South India.

Maplestone and Bhaduri (1937) reviewed all the literature on Cycticercus cellulose infection in pigs and man. In 1942 they examined 100 pigs at Calcutta with certained other animals for the presence of Trichinella spiralis with negative results in the former, although they recovered it from a cat.

Feeudanoplocephala crawfordi Baylis, 1927 from Madres for the first time in domestic pigs in India gave an illustrated account of the species.

Buckley (1939) recorded E. buski in 59.7% and G. hominis in 41.2% of human population of Assam.

Chatterjee (1939) recorded Setaria bernardi Ralliet and Henry, 1911 from pigs in India.

Wolfgang (1953) has described a new genus of nematode <u>Pseudocrazia</u> (Oxyuridea) from domestic swine in India.

Remanujacheri and Alwar (1953) recorded

Simondsia paradoxa from domestic pigs for the first time
in India and redescribed the species. The authors (1954)
subsequently recorded A. sufrantyfex for the first time

in Madras with incidence of 4% and made some preliminary observations on life cycle, though they failed to infect the small host.

Varma (1954) studied <u>Gastrodiscoides</u> from both human and porcine sources from Bihar. In his morphological and histological studies on whole mounts and sectioned specimens he found some differences in relative size of the parasites, the character of their genital papilla/cone and relative disposition of the testes and felt it necessary to maintain separate varieties for the specimens from the two sources (<u>G. hominis</u> for man & <u>G. hominis</u> var. suis for pigs) until their life cycle was worked out and it was conclusively proved that they either belonged to the same species or represent two different ones.

Srivastava & Peter (1954) studied the life history of A. sufrartyfex Lane, 1915 and recorded a high incidence of the parasite in Bareilly.

Sinha (1957) recorded a new oxyurid from pigs in India and named it Syphacia grivastavzi n. sp.

Thapar (1956) during his systematic survey of helminth parasites examined material from Calcutta and Darjeeling and recorded 2. buski, Gastrodiscus aegyptiacus, G. hominis, Ascarops strongylina, Ascaris lumbricoides, Cruzia orientalis, Metastrongylus

elongatus, Cesophagostonum dentatum from pigs.

Alwar (1958) examined 50 pigs for the incidence of helminth parasites and found every adult pig infected, majority of them harbouring 3 to 5 species with the maximum recovery of nine species from a single animal. He encountered seventeen species with high incidence of A. strongylina (96%), P. sevalatus (96%), S. paradoxa (68%), Oesophagostomum sp. (30%), P.crawfordi (45%) and Hydatid (30%). He found low incidence for A. sufrartyfex (4%), S. suis (8%), C. cellulose (10%), C. tenuicollis (2%), S. dentatus (4%), M. apri (8%), T. trichura (10%), Streptopharagus sp. (2%), Onchocerca sp. (10%) and Enterobius vermicularis (4%).

Rai & Ahluwalia (1958) reported from Aligarh on the incidence of A. strongyling, P. saxalatus,

O. dentatum, S. dentatus, S. incognitum and A.sufrertyfex with a brief description of the latter.

Subsequently Ahluwalia while conducting a survey of helminth parasites of domestic pigs in Western U.P. recorded nineteen species and in his subsequent papers (1959, b, 1960 a, b, c & 1962) has discussed the morphology, pathology and other aspects of some of them.

In Bihar there seems to be no information available on the parasites of pigs except that of Varma (loc. cit.) on G. hominis var. suis and F. buski.

Viz. Eineria scabra, E. spinosa, E. polita E. perminuta

B. debliccki and Isospora suis from Isatnagar. There
does not seem to be any published record, to the best
of the knowledge of the author, on the balantidiosis of
swine in India except the mention of its fair occurrance
in Calcutta by Encyles (1928) in his book.

MATERIALS AND METHODS

Materials from pigs were collected from a local slaughter-house at Jajura and from Livestock Research Station, Bihar, Fatna, where pigs were kept and sacrificed for experiments on the production of Swine Fever Vaccine. Four Yorkshire pigs were examined postmortem at Government Cattle Farm, Cauriakarma situated on the Chhotanagpur Plateau. Pigs for slaughter at Jajura were brought from the districts of Patna, Gays, Monghyr, Santhal Paragana, Arrah, Darbhanga and Muzaffarpur, all lying in the Gangetic plains of Bihar.

Fart of the examination was done at the place of slaughter itself. While eviscerating, the peritoneal cavity and musculature were examined for larval or adult parasites and some gross pathologic lesions. Then tongue, oesophagus, stomach, intestine, lungs with trachea, heart, liver, spleen, pancreas, diaphragm, kidney with ureter and cysts in kidney-fat were removed and examined. Some of them were taken to the laboratory for thorough search.

Mesenteric veins, by spreading the mesentery and oesophageal wall were examined for parasites.

Stomach worms were mostly embedded in thick mucus adhering to the stomach mucesa. Simondsia males were

embedded in mucosal pigs of fundus region, both the ends projecting outside. They were drawn out with the help of forceps. The females were embedded in hard submucosal cysts of fundus region, which were removed intact with great difficulty by cutting open the cysts.

Intestinal mucosa was also examined for adhering parasites or parasitic nodules in the wall, the latter were pressed between the slides and examined for the presence of larvae.

A small quantity of faeces was removed from caecum and rectum for the examination of protozoan parasites.

Fancreatic ducts were cut open and parasites recovered. The bileducts and gallbladder were also examined similarly. The liver was examined for schistosome by trimming the edge half inch all around and putting a jet of water in portal veins. Water in jet came out at the trimmed edges and the ejected water was examined for parasites.

Lungs, like other organs, were examined grossly for any cyst or nodule present. The traches bronchi and bronchioles were cut open and examined for parasites; lungworms were found embedded in frothy mucus. Hydatid cysts were removed and put in 10% formalin. A small thin slice of diaphragm muscle was pressed between two

glass pieces, screwed up and examined under binocular for Trichinella spiralis larvae.

Kidney-worm cysts embedded in peri-renal and peri-ureteral fat were opened and parasites recovered.

The collections were kept in normal sline solution in separate Fetri dishes and were washed three or four times to clean the parasites of attached mucus or debris. The nematodes were then fixed in 70% steaming alcohol and preserved in 5% glycerinated alcohol in properly labelled and well stoppered phials.

The trematodes were fixed by pressing them gently between two glass slides or putting a cover slip over it and preserved in 5% formal-saline or hot A.F.A. solution. With the latter, after 24 hours, the specimens were removed and preserved 70% alcohol.

The tapeworms were fixed by constantly dipping them in 5% lukewarm formal-saline solution by holding the teil end of the tapeworm with forceps and drawing it along the edge of the beaker. By repeating the process 10 to 15 times, the worms became completely flattened. Head of the larval cysts were pressed between slides and preserved in 5% formal-saline.

Trematodes were stained with Borax carmine,
Semichons carmine, Gover's stain and Acetic alum carmine
and tapeworms with Borax and Acetic alum carmine.
Permanent mounts were made for identification and

morphological studies. Serial sections were prepared for some trematode and cestode by usual paraffin embedding technique and stained with Haematoxylin-Bosin.

Hematodes, for detailed morphological study and identification were cleared in glycerine in case of thin worms and lactophenol in case of thicker ones. End-on preparations were made of the specimens of Ascaria cleared in glycerine and croosote.

Tissues with worms embedded or showing any gross pathology suspected to be due to parasitic infection were fixed in 10% formol-saline or Bouin's fluid. Standard procedures were followed for dehydration, clearing and embedding in paraffin. Serial sections of 5 & 7 microns thickness were made and stained with Haematoxylin-Sosin.

Besides the collection of faccal samples intended to detect the protozcan infection in 154 pigs examined postmortem, 100 faccal samples from deshi pigs at Fatna and 336 samples from pigs at Gauriakarma were examined to determine the helminth and protozcan infections.

Faccal samples were collected from rectum and examined fresh.

Qualitative examination of facces was done as follows for all the samples.

1. Direct smear method: - Two thin films, about 2 mm.

apart, were made on a clean microscopic slide with 1-2 mgm. of faeces, one in physiological saline solution and the other in iodine solution (filtered saturated solution of iodine in 1% potassium iodide). The unstained film was found particularly suitable for the study and detection of living protozoan trophozoites like Balatidium coli and parasitic larvae and the stained film for protozoan cocysts.

- 2. Centrifugal Sedimentation Nethod: This method was found fairly useful for the concentration of coccidian occysts and helminth eggs particularly cestode and tremadoes which generally come in sediment when floating medium is used.
- 3. Centrifugal Floatation Method: After sedimentation, sediment was resuspended in floating medium, recentrigugalised, giving the centrifuge tube rest for five minutes, upper soum was removed and transferred on to a microscopic slide with the help of a horizontally bent loop of wire. Saturated solution of sodium chloride and sugar solution (sp. gr. 1.200) were the floating media commonly employed, which gave high concentration of protozoan cysts and helminth eggs.

Samples positive for <u>Balantidium coli</u> were preserved in 5% formol-saline for further morphological study. At the same time faecal smears were made on clean

slides, fixed in Schauddinn's solution while still partly wet and were stained with Heidnhain's iron haematoxylin.

Out of positive samples for coccidia, 30 samples (eight from Gauriakarma and twelve from Patna) were randomly selected and washed in water with the help of centrifugal-sedimentation method and kept in 2.5% Potassium dichromate solution at laboratory temperature for sporulation and specific identification. A part of the sample was preserved in 5% formol-saline for the study of unsporulated occysts. Sporulation time was also observed.

Randowly selected pieces of caccum and intestine from positive cases of <u>B. coll</u> and caccidia were preserved in 10% formol-saline for histological studies to show any tissue phase of the parasite.

Measurements recorded for all the parasites described were taken with the help of stage and oculer micrometers the bigger ones were measured with help of standard scale.

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1.

TABLE NO. II(a).

Table showing the percentage of infection with different Trematodes in Domestic Pigs examined postmortem.

Sl.	-	me of the arasite	inc. of ipigs lexamined	No. found infected	Percentage of infection
1.	0.	noverca.	154	107	69.48
2.	F.	buski.	154	24	15.58
3.	A.	sufrartyfex.	154	49	32.47
4.	G.	hominis	154	6	3.90

TABLE NO. II(b).

Table showing the percentage of infection with different Cestodes in Domestic Pigs examined postmortem.

Sl.I	Name of the parasite	No. of Ipigs lexamined	No. found	Percentage of infection
1.	P. crawfordi.	154	8	5.20
2.	C. cellulose.	154	11	7.14
3.	C. tenuicollis.	154	4	2.60
4.	Hydatid cysts.	154	9	5.84

TABLE No. II(c).

Table showing the percentage of infection with different Nematodes in Domestic Pigs examined postmortem.

distribution of	pinane i	The state of the s			
Sl.j	-	me of the parasite	No. of lpigs lexamined	No. found infected	Percentage of infection
1.	A.	strongyling.	154	87	56.49
2.	P.	sexelatus.	154	68	44.15
3.	<u>s.</u>	paradoxa.	154	47	30.52
4.	A.	lumbricoides.	154	36	23.38
5.	M.	apri.	154	3	1.95
6.	S.	dentatus.	154	123	79.87
7.	0.	dentatum.	154	53	34.49
8.	0.	quadrispinulati	. 154	24	15.58
9.	0.	brevicaudum.	154	48	31.17
10.	T.	trichiura.	154	7	4.55

TABLE NO. III.

Table showing the multiple infection rate with different Helminth and Protozoa in 154 Pigs examined postmortem.

o. of pecies arboure	No. of pi linfected ed [with [Helminth]	gslPercentage i of linfection i	Opigs	X
n 1	1	0.65	26	16.9
1.	6	3.9	80	52
2.	16	10.4	48	311
3.	26	16.9		
4.	20	13		The second section is a second
5.	31	21.3		
6.	29	18.8		
7.	12	7.8		
8.	11	7.1		
9.	2	1.3		

TABLE NO. IV(a).

Table showing the percentage of infection with different helminths in Deshi Domestic Pigs at Patna as revealed by faecal examination..

Sl.I	parasite	No. of pigs examined	infe	cted	Percen- tage of infection
1	2	3	4	5	6
	TREMATODES.				
1.	Opisthorchis sp.	100	38	17	55
2.	Fasciolopsis sp.	100	3	6	9
3.	Echinostome	100	15	8	23
4.	Gastrodiscoides sp	. 100	1	1	2
1.	Pseudanoplocephala sp.	100	2	6	8
	NEMATODES.				
1.	Spirurid worms	100	7	48	55
2.	Ascaris sp.	100	2	40	42
3.	Oesophagostomum sp	. 100	3	54	57
4.	Trichuris sp.	100	-	3	3
5.	Metastrongylus sp.	100	2	•	2

...

TABLE NO. IV(b).

Table showing the percentage of infection with different belminths in Yorkshire Pigs at Gauriakarma Farm (Hazaribagh) as revealed by faecal examination.

S1.0 No.1	Name of the parasite	No. of Ypigs lexamined	No. f linfed	ted (Heavy)	Percent tage of infection
X	TREMATODES.	1 3	1 4	1 5	6
1.	Opisthorchis sp.	336	59	7	19.64
2.	Fasciolopsis sp.	336	11	6	5.06
3.	Echinostome	336	19	10	8.63
4.	Gastrodiscoides sp.	336	3	-	0.89
Marine and Art of	CESTODES.	Parantis a restormation parameters sprove gastination	DOWNSON PROPERTY.		variant tida vilon is Carletovia mesterninos estanda
1.	Pseudanoplocephala s	p. 336	1	3	1.29
2.	NEMATODES.			a recognise different and the season	And the last and heaven's the right and heave have been a
1.	Spirurid worms	336	65	92	46.32
2.	Ascaris sp.	336	42	141	54.46
3.	Oesophagostomum sp.	336	31	125	53.00
4.	Trichuris sp.	336	75	138	63.39
5.	Metastrongylus sp.	336	42	36	23.21

000

TABLE NO. V(a).

Table showing the percentage of infection with different Protozoa in Deshi Domestic Pigs examined postmortem at Patna.

S1. Name of the No. protozoa		No. of pigs		No. found infected infected infected infected infected infected infection in the second in		Percentage of
		le	xamined	Light	Heavy	infection
1.	Coccidia.		154	19	54	47.4
2.	Balantidium c	oli.	154	5	98	66.88

TABLE NO. V(b).

Table showing the percentage of infection with different Protozoa in Deshi Domestic Pigs at Patna.

No. I protozo	a Ip. Ie	o. of in igs i i xamined (Li	nfecte ght He	ad inf	rcentage of fection
1. Coccidia		100 1	6 4	11	57
2. Balantid	ium coli	100	- 7	2	72

TABLE NO. V(c).

Table showing the percentage of infection with different Protozoa in Yorkshire Pigs at Gauriakarma Farm (Hazaribagh).

Sl.I No.I	Name of the protozoa		ÎNo. of Ipigs Yexamined	No. Linfe Light	found (cted I	Percentage of infection
1.	Coccidia		336	47	94	42
2.	Balantidium	coli	336	33	96	38.4

TABLE NO. VI.

Table showing the common multiple infections of Coccidian species in Domestic Pigs.

Sl. I	mul	ture of ltiple Tection		No. of isamples lexamined	No. found infected i	Percentage of infection
1.	三.	debliecki perminuta.	ê:	30	7	23.3
2.	EL.	debliecki scabra.	હે	30	5	16.6
3.	E.	perminuta scabra.	&	30	14	46.6
4.	MEN.	debliecki perminuta. scabra.	,	30	3	10.0

The extend of helminth and protozoan infections in domestic pigs is quite apparent from the fore-going tabular statements. Eighteen species of helminths and four species of protozoa have been found to parasitise domestic pigs in this survey. In addition, the work has made certain intersting revelations about relative preponderance of different species, multiple infections, intensity of infection, variation in geographical distribution and distribution of parasites within the host's body with their associated pathology.

Opisthorchis noverca and Stephanurus dentatus
have been found to be the commonest helminth parasites
in deshi domestic pigs with incidence as high as 69.48%
& 79.87% respectively (Tables II (a) & II (c).). Spirurid
stomach worms are also fairly common with incidence of
63% and 55% as revealed by postmortem and faeces
examinations respectively among deshi pigs at Patna and
46.72% among Yorkshire pigs at Gauriakarma Farm. Similarly
Oesophagostomum spp. (0. dentatum, 0. quadrispinulatum,&
0. brevicaudum) have incidence as high as 46.1%, 57.0% and
53.0% in the same sequence as spirurid worms.

Cases of multiple infections were very common (Table No. III). No pig was found to be free from parasites. Maximum number of species recovered from a single pig was as high as eleven (nine helminths, coccidia

B. coli). As apparent from Table No. III most of the animals harboured between three to five species of helminths with frequent combinations of <u>O. noverca</u>, <u>S. dentatus</u>, <u>A. strongylina</u>, <u>P. sexalatus</u>, <u>Simondsia paradoxa</u>, <u>O. dentatum</u>, <u>O. quadrispinulatum</u>, and <u>O. brevicaudum</u>. Similar multiple infections were revealed by faecal examinations.

Intensity of infection has not been indicated in the tabular statements, but maximum number of parasites recovered from a single host was 0. noverca - 30;

F. buski - 211 (A large portion of the small intestine was found blocked); A. sufrartyfex - 174; A.lumbricoides var. suum - 11; T. trichiura - 106; M. apri - 120 and Oesophagostomum spp. (O. dentatum, O. quadrispinulatum & O. brevicaudum) were found be setting the whole of caecum and colon in numbers more than 2000. Among the spirurid stomach worms, Ascarops strongylina with maximum of 78 was always in overwhelming number over the other two species, P. sexalatus and S. paradoxa. P. sexalatus was never found more than ten in number. Simondsia females embedded in cysts were recorded with maximum number of 12.

Among protozoa, B. coli was found in overwhelming number, but coccidian occysts were generally few. Sporulation & identification of coccidia from 30 pigs revealed the occurrence of three species Eimeria deblicaki,

E. scabra and E. perminuta and indicated the presence of mixed infection with two or three species. Infection with B. coli was never found to be associated with any gross pathological lesions. Even histopathological examination of the affected caecum failed to reveal any marked change or parasite in the tissues.

Faeces examination revealed striking differences in infections among deshi pigs examined in rural areas of Gangetic plains and those white Yorkshire pigs maintained at Gauriakarma Farm situated on Chhotanagpur plateau. This difference is particularly marked in respect of infections with Metastrongylus and Trichiuris spp. which in contrast to other species, showed higher incidence among pigs at Government Farm, Gauriakarma.

This difference was highly significant.

The following interesting observations were made in relation to predilection site of the parasites:
(1) Opisthorchis noverca in all the cases examined was found in the pancreatic duct, sometimes even blocking it with evidences of host tissue reaction as revealed by epithelial prolifration of the duct and subepithelial infiltration.

(2) Ascaris adults were recorded from bile ducts and surprisingly enough one adult and two juvenile forms were found to be embedded in the liver parenchyma itself.

On histopathological examination, they were found to be embedded outside the bile duct in the portal area surrounded by extensive proliferation of fibrous connective tissue.

(3) Adults and juvenile forms of Stephanurus dentatus were found in the pelvis of kidney, liver, lungs, pancreas and thoracic and abdominal cavities.

Studies on individual parasites and associated gross and histological pathology are recorded and discussed separately for each species of parasites encountered.

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CESIODA. >

1. Family -- Anoplocephalidae Choledkovsky, 1902.

Genus -- Pseudanoplocephala Baylis, 1927.

Species -- P.crawfordi Baylis, 1927.

Host -- Domestic pigs.

Habitat -- Small intestine.

Locality -- Patna and Hazaribagh.

The genus Pseudanoplocephala was created by Baylis, 1927 for an anoplocephalid worm recovered from a wild boar in Ceylon. He named the species P. crawfordi, 1927 Mudaliar and Gopalkrishnan (1938), recording the parasite for the first time in this country, gave an illustrated account of the species. The genus Pseudanoplocephala was treated by Bhalerac (1935) under the sub-family Anoplocephalizae Furhrmann, 1907 of Anoplocephalidae Choledkovsky, 1902. According to Ahluwalia (1959) this genus has been included under the sub-family Anoplocephalinae Blanchard, 1891 by Spasski (1951) which has recently been revised by Lopez-Neyra (1954) who has reduced the genus Pseudanoplocephala to a sub-generic rank under Anoplocephala Blanchard, 1848, the species thus becoming according to him Anoplocephala (Pseudanoplocephala) crawfordi (Baylis, 1927) Lopez-Neyra. Ahluwalia (loc. cit.) while recording the

parasite from U.P. redescribed the species. Noting for the first time the presence of a distinct but weak rostellum in the scolex, he does not accept the reduction made by Lepez-Neyra (loc. cit.) to a sub-generic rank. Alwar (1958) also recorded this parasite from 46% of domestic pigs examined at Madras and Thapar (1956) recorded

Pseudanoplocephals sp. from wild boar in U.P. In this survey it has been recorded from eight pigs out of 154 examined postmortem. Eggs have been encountered in faecal examinations at Patna and Gauriakarma (Hazaribagh).

The present specimens agree in morphological details with the description given by Baylis (1927), Mudaliar & Gopalkrishnand (loc. cit.) and Ahluwalia (loc. cit.). There is nothing to add on this point. But the scolex measuring 0.4 mm. in diameter with 4 suckers, showed a weak rostellum measuring 0.8 mm. in diameter, thus agreeing with the first observation of Ahluwalia (loc. cit.).

- II. Family Taeniidae Ludwig, 1886.
 - 1. Genus -- Taenia Linnaeus, 1758.
- (1) Species -- Taenia solium Linnaeus, 1758.

Larval stage-Cysticercus cellulose.

Host -- Domestic pigs.

Habitat - Tognue, cesophagus, stomach, intestine, diaphragm, heart and other skeletal museles.

Locality -- Patna and Hazaribagh.

This larval stage of human tapeworm I. solium was encountered in 7.14% of pigs examined. In one Yorkshire pig which died after a prolonged illness at Gauriakarma Farm, practically all the organs including heart and musculature were infested with the cysts. The death might have been due to this heavy infestation. The milky white spots indicating the position of head were visible in infected muscles or organ justifying the name 'measly pork'.

The bladder worm removed from the muscle or organ measures 7-11 x 5-7 mm. and is filled with clear fluid, with a minute milky white head invaginated into it. The pressed and stained specimens of scolex show 4 suckers and a conspicuous rounded rostellum, armed with a double row of large and small hooklets numbering 26-32 and measuring 0.16 to 0.17 mm. and 0.12 to 0.14 mm. in length respectively.



(ii) Species - Taenia hydatigena Pallas, 1766.

Larval stage-Cysticercus tenuicollis.

Host -- Domestic pigs.

Habitat -- Attached to liver, mesentry and free in abcominal cavity.

Locality -- Patna.

This is the larval intermediate form of dog tapeworm Taenia hydatigena. This is not very common in pigs but have cosmopolitan distribution in sheep, goats and other domestic animals. In the present study it has been found only in 2.6% of the pigs examined. In India it has been recorded from Madras (Alwar, 1958) and U.P. (Ahluwalia, 1960).

This has the appearance of a bladder filled with clear fluid and is enclosed in a delicate covering. It has a thin invaginated neck bearing scolex which is marked as white spot. The cyst measures 0.5 to 2.5 inches in length. The scolex has four suckers with 22.32 hooks arranged in two rows. The larger ones measure 166-178/4 and smaller 110-130/4.

2. Genus -- <u>Echinococcus</u> Rudolphi, 1801.

Species -- <u>E. granulosus</u> (Batsch, 1786)

Rudolphi, 1805.

Larval stage-Hydatid cyst.

Host -- Domestic pigs.

Habitat - Lungs, liver and spleen.

Locality -- Patna and Hazaribagh.

Hydatid cysts, besides pigs, have been reported from numerous domestic and wild mammals including man.

Cysts encountered are of two structural types, unilocular and multilocular, each of them supposed to be the larval stage of two different species of canine tapeworm

Echinococcus granulosus (Batsch, 1786) Rudolphi, 1805 and Echinococcus multilocularis (Leuckart, 1863) Vogel, 1955 respectively.

In the present investigation the cysts encountered were only of unilocular type and were found only in 5.84% of the pigs examined. The size varies from 1-4" in diameter, approximately spherical in shape. Contrary to the previous reports of liver as a relatively favoured site for the echinococcosis in pigs, in the present survey the lungs were found to be more favoured site, where the cysts attained a large size and were fertile. In liver and rarely in spleen the cysts were smaller 1 to 2 inches in diameter and often sterile

containing clear cystic fluid and glistening internal wall.

The cysts after removal from the organs were put in 10% formalin. After cutting open, the sediment of the cystic fluid after centrifugal sedimentation and scrapings from cystic wall were examined under microscope for the presence of scolices and brood capsules. Even with necked eye the wall of fertile cysts gives grained appearance. The scolices and brood capsules were stained with acetic acid carmine and permanent zmounts were made.

Scolices were found both on the germinal layer of the wall and mostly inside the brood capsules. The latter were attached inside to the wall and also free inside the cysts.

IRBMATODA

I. Family -- Fasciolidae Railliet, 1895.

Genus - Fasciolepsis Looss, 1899.

Species - F. buski (Lankester, 1857)
Stiles, 1901.

Host -- Domestic pigs.

Habitat -- Small intestine.

Locality -- Patna and Hazaribagh.

This giant intestinal fluke or Busk's fluke of man and pig is common in South-East Asian countries.

Bhalerao (1931) recorded it from domestic pigs in Bengal and Buckley (1939) from human population in Assam. It has later been reported in swine from Bengal (Thapar, 1956) and U.P. (Ahluwalia, 1959).

The body of this fluke measures 20 mm. to 76 mm.

**Elong and 10 to 16 mm. wide. Cuticle have spines. Shoulder
is absent. Ventral sucker is much larger than oral. Pharynx
and a short cesophagus are present. Intestinal caeca with
two curves reach the posterior extremity of the worm.

Testes are much branched and tandem. The long and tubular
cirrus sac arising from vas deferens halfway between
ootype and ventral sucker opens anterior to the latter.

It contains convoluted seminal vesicle and prostate gland.

Ootype is surrounded by Mehlis glands. The ovary is
branched and right to the mid-line. Vitellaria occupies

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Fig. 5 A portion of small intending of the city of the

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lateral fields. Uterus meanders between ootype and genital pore. Eggs are operculate measuring 130 to 140 X 72 to 85 microns.

Pathogenicity: The parasites when few in numbers are not associated with any appreciable pathological lesion in swine. Heavy infection in small intestine of one pig was found obstructing the passage of food resulting in grave consequence. Numerous worms were found attached to the intestinal mucosa with local centre of inflammation at the point of attachment. The death of swine, which died after a short illness, might have been due to the obstructive and traumatic damage caused by the parasite.

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II. Family -- Opisthorchidae Braun, 1903.

Genus -- Opisthorchis Blanchard, 1895.

Species -- Opisthorchis noverca Braun, 1903.

Host -- Domestic pigs.

Habitat -- Pancreas.

Locality -- Patna and Hazaribagh.

Levis and Cunningham (1872) first identified an opisthorchid from a dog in India as Distomum conjunctum Cobbold, 1858. McConnell (1876 & 1878) recorded similar parasites from two Mohammadons at Calcutta and described them as Distomum conjunctum. Braun (1903) pointed out the difference between Cobbold's species and that recorded by these authors and renamed the latter as Opisthorchis noverca. Since then the occurrence of this parasite has been reported several times in dogs by various authors in India (Bhalerao, 1931), but there is no further record from man. The only record of its occurrence from domestic pigs in India appears to have been made by Bhalerao (loc. cit.) from 10 out of 49 pigs examined at Calcutta. He regarded the lobular and recunded appearance of testes as a character to create two distinct varieties; O. noverca var. lobata and O. noverca var. orbiculata. Yamaguti (1958) has treated this species under the genus Amphimerus Barker, 1911, which was created on the character of vitellaria in which the latter extended backward in the testicular zone, usually with a break at the level of ovary. He dropped A. caninum

Barker, 1911; O. noverca Braun, 1903; O. noverca var.lobata
Bhalerao, 1931 and O. noverca var. orbiculata Bhalerao, 1931.

In the present study the lobation of testes appears to be variable; even in the same specimen one testis may show labulation and the other may be rounded. Similarly vitellaria, apparent from the description given below, have failed to show the characteristic backward extension in testicular zone with break at the level of ovary. Bhalerao (loc. cit.) also failed to see this typical condition in his specimens. Thus, the author finds full justification in identifying his specimens as Opisthorchis noverca Braun, 1903.

During this investigation the incidence of this parasite among domestic pigs has been found to be very high; 107 p igs out of 154 examined postmortem were found to harbour the parasite in pancreatic ducts along and on no occasion in liver or intestine. This peculiar habitat of this parasite in swine host appears to have been observed for the first time.

The parasite when fresh is faint pink and transparent. Body is ovoid 3.5 to 6 mm. X 1 to 2 mm., flattened, tapering anteriorly. Cuticle have fine spines. The suckers are close together oral being much developed and ventral small and nearly spherical. There is a short prepharynx and well developed pharynx. Desophagus is short. Intestinal caeca run on either side reaching the posterior end of the body. The genital pore is infront of the

ventral sucker, which in many specimens stand out prominently forming stalk or pedicel. The excretary vesicle is Y shaped, the stem passing between the testes. Cirrus sac is absent. Testes are rounded or lobate placed more or less obliquely one behind the other. The size, shape and lobulation of the testes are variable. Recepticulum seminis is well developed, The ovary is usually trilobed and lies infront of the anterior testis. The uterine coils fill the intercaecal space to open into the genital pore infront of the acetabulum. The vitellaria, grouped in follicles, eight in number on either side extend from behind the acetabulum to the level of the ovary, in some of the specimens to the level of the anterior testis without a distinct gap at the level of the ovary.

Pathogenicity: - The parasited was found embedded in pancreatic duct. In heavy infection, most part of the ductal system was occluded with the parasites. At times the parasite were found to be outside the pancreatic duct.

Histologically different degrees of changes were observed in ductal and periductal tissue. Proliferation of the ductal epithelium was well marked. At places the epithelial proliferation was so much advanced that complex folds projected into the lumen of the duct. The section of these folded epithelium looked at places like

propria, there was infiltration of eosinophile and some lymphocyte. Varying degrees of peri-ductal fibrosis was evident. Just outside the epithelium and tunica propria fibroblasts and fibrous tissue in different degrees of maturation were laid down.

Thus the picture presented were that of chronic proliferation of the ductal epithelium and chronic pancreatitis evidenced by the infiltrative cells. As far as could be ascertained from the available literature this is the first record of pathological changes evoked by Opisthorchis noverca in the pancreas of pigs.

In some sections, the parasites were found outside the duct, in the substance of the pancreas. But the inflammatory changes were not marked. This might have been due to postmortem migration.

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III. Family -- Echinostomatidae Poche, 1926.

Genus - Artyfechinostomum Lane, 1915.

Species - A. sufrartyfex Lane, 1915.

Host -- Domestic pigs.

Habitat -- Small intestine.

Locality -- Patna.

The controversy in regard to the nomenclature and taxonomic position of this parasite is not yet finally settled. Bhalerao (1931) recording this echinostome for the first time from the domestic pigs in Bengal under the name Paryphostomum sufrartyfex (Lane, 1915), gave a detailed account, discussed texonomy and placed it in the genus Paryphostomum (Dietz, 1909) of Echinostomatidae. This species had originally been described by Lane (1915) as Artyfechinostomum sufrartyfex from a girl in Assam. In 1911, leiper described an echinostome from Tamil coolies at Singapore under the name Echinostoma malayanum. Faust (1930) in his book dealt with lane's species as Echinostoma sufrartyfex (Lane, 1915) and separately treated Echinostoma malayanum (Leiper, 1911). Bhalerao (1935) followed his earlier account recording this species as a parasite of man & pig. Mendheim (1940), however, as quoted by Ahluwalia (1961) retained Lane's genus Artyfechinostonum with two species A. sufrartyfex and A. malayanum distinguishing them by the number of collar spines. From Madras Varmah and Reddy (1951) reported Paryphostomum sufrartyfex from a Hindu boy and subsequently Ramanujachari and Alwar (1954) from

domestic pigs. Faust & Russell (1957) in the recent eddition of their book have described this species under the name Paryphostomum sufrartyfex (Lane, 1915) Bhalerao, 1931 taking A. sufrartyfex Lane, 1915; Euparyphium malayanum (Leiper, 1911) and Echinostoma sufrartyfex (Lane, 1915) Faust, 1929 as its synonym. Rai & Ahluwalia (1958) and later Ahluwalia (1961) describing the specimens from pigs in U.P. added some informations morphology, particularly spinose character of the cirrus (it has also been mentioned by Faust & Russell, 1957) and felt that the forms so far described from pig and man under different specific names really belonged to the species Artyfechinostomum sufrartyfex with no clear cut difference, including even the Malayan fluke, Echinostomum malayanum (Leiper, 1911) as synonym. The present specimens, however, agree in morphological details with Artyfechinostomum sufrartyfex Lan, 1915, the important salient features of which are given below.

in the mounted stained preparation. Ventral surface of the body is spinose & dorsal aspinose in character. The anterior most region, marked by small notch in the plane of ventral sucker, is encircled by collar of 43 spines interrupted ventrally. Five spines on each side constitute the corner spines with one larger in each set. At the centre of spined portion lies the oral sucker. Muscular pharynx is present. Ventral sucker is prominent with

width of 1.5 mm. Genital pore opens infront of ventral sucker. Testes are tandem and deeply lobed. Vas efferentia from both testes join cirrus sac separately. Cirrus pouch is enormously enlarged extending from Genital pore much beyond the ventral sucker. It contains seminal vesicle, a prostate region and a much coiled cirrus with spinose outer end. The overy is ovel or spherical in shape, measuring 0.5 to 0.8 mm. in diameter lying to the right of the midline anterior to testes. Cotype is near middle of the body, uterus packed between octype and ventral sucker. Vitellaria occupy the latral fields from the region of ventral sucker to the posterior extemity where they meet in the mid-plane. Mehlis gland is prominent. The operculate eggs measure 90 to 120X60 to 70/u.

IV. Family -- Paramphistomidae Fischoeder, 1901.

Ganus - Gastrodiscoides Leiper, 1913.

Species -- G. hminis (Lewis & McConnell, 1876)
Leiper, 1913.

Host -- Domestic pigs.

Habitat -- Caecum & Colon.

Locality -- Patna.

Lewis and McConnell (1976) described the parasite as Amphistoma hominis from an assamese. Stephens (1906) redescribed the anatomy and assigned it to the genus Gastrodiscus Leuckart, 1877. Subsequently, Leiper (1913) transferred it to his newly created genus Gastrodiscoides distinguishing it from Gastrodiscus on account of lack of pepillae on the ventral surface.

Besides Bengal & Assam it has been recorded in man from Bihar and Orrisa by Bose, 1934. In swine it has been reported from Assam (Buckley, 1939), Bengal (Bhalerao, 1931) and U.P. (Ahluwalia, 1959). In the present study the incidence has been found to be 25 3.9%. The forms occurring in swine and human were considered identical until Varma (1954) examining the specimens from human and porcine sources found some difference in size, character of genital papillae/ cone and relative position of testes and felt it necessary to create separate varieties for specimens from two sources (G. hominis from man and G. hominis var. suis from pigs). Later

Ahluwalia (1960) while examining the material from pigs only, concludes that morphologically, the specimens from human and percine infections are indistinguishable and should be considered to fall within the same species until it is established on experimental basis, that the two are different physiological strains.

The amphistome has fleshy pink coloured body with an anterior conical postion nearly 2 mm. long and posterior discoidal region. Size varies from 8 to 12 mm. long and 5 to 8 mm. wide. Body is aspinose and discoidal portion has got non-papillated ventral concarity. Oral sucker is sub-terminal. Mouth is connected with two lateral pouches. Oesophagus has posterior bulb. Intestinal caeca reach the anterior border of acetabulum. Acetabulum. occupies the ventral rim of the posterior part of the worm. Genital cone, where genital pore opens, is situated slightly behind the middle of the conical portion in the median line. Testes are large, lobulated and tandem in position, the anterior one smaller and posterior one is larger and distinctly lobulated. Cirrus pouch is absent and seminal vesicle is much coiled.

The small ovary lies behind the testes and the cotype to right of the ovary. The uterus coils upto the genital pore. The vitallaria are limited to the lateral areas of discoidal portion. The operculated eggs measure 150 to 165 X 70/u.

NEMATODA

I. Family -- Ascaridae Cobbld, 1864.

Genus -- Ascaris Linnaeus, 1758.

Species -- Ascaris Lumbricoides Linnaeus, 1758.

Synonym -- A. suum Goeze, 1782.

A. suis Gmelin, 1790.

A. suilla Dujardin, 1845.

Host -- Domestic pigs.

Habitat -- Small intestine & liver (?).

Locality -- Patna and Hazaribagh.

It has also been found in man, certain large apes, sheep, squirrel and dog. This is one of the well known parasites of man known from very early times and voluminous literature can be cited on its morphology and biology.

thought to be morphologically and serologically indistinguishable till Sprent (1952), examining the material from human and pigs, pointed out that lip denticles of the pig ascarids form a conspicuous row of more or less equilateral triangle and that the edges of the denticles are straight, while in those of human ascarids the denticles are less conspicuous, smaller, having concave edges. Later Abdulrachman and Joe (1954) examining the material from both the sources demonstrated the differences in the lip denticles, although there were

intermediate forms in a few cases. Physiologically both were found not to be interchangeable by means of experimental infection (Ransom & Foster, 1920; Koino, 1922 and Payne et al, 1925). But this was later refuted by De Boer (1935) who concluded that cross infection from human ascarids to pig can take place, Thus, as Lindquist (1959) feels, the whole problem of cross infection needs more examination, before taking swine ascarid to be physiologically different. He, as also chandler (1961) and some other authors, has referred this species as Ascaris lumbricoides var. mum.

The incidence of infection was found to be 23.38% in domestic pigs. To study the comparative morphology 10 specimens were collected from an 8 year boy at Government Farm Gauriakarma passed in his stool after piperzine treatment, and 10 specimens were obtained from the Pathology Department of Patha Medical College. This parasite has been recorded from domestic pigs in India by Maplestone (1930), Thapar (1956) & Ahluwalia (1958 & 1959).

End-on preparations of 20 human ascarids and 20 swine ascarids were examined of glycerine cleared specimens to show the difference, if any, in the character of denticles on the dentigerous ridge. In 14 specimens from the pigs the denticles are prominent, in the size of an equilateral triangle and form a conspicuous row on the dentigerous ridge. In four specimens these were not very

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prominent and in rest two, the denticles were like those of human ascarids. The denticles of human ascarids are much smaller and inconspicuous with more rounded points. Pathology: - Any outstanding gross pathology was not observed in the intestine containing mature worms. This may apparently be due to the fact that heavy intestinal infection was not observed. On three occasions the juvenile and adult parasites were found embedded in the bile duct and in the liver parenchyma itself. The bile duct was seen ocluded. The liver was pale and slightly enlarged. Cirrhosis was marked by induration, distinct lobulation and well marked white spots on the surface, indicating the areas of extensive fibrosis. Histopathology: - In addition to bile ducts, the parasite was found lodged in portal tract outside the duct . Portal area showed increased fibrosis particularly encircling the parasite. Infiltration with lymphocytes and eosinophiles was evident. Fibrous strands extended to the adjacent lobules presenting a typical picture of multilobular cirrhosis. In the encircled lobule the hepatic laminae were disorganised with individualisation of hepatic cells. Different degrees of degenerative changes from cloudy swelling to fatty degeneration were seen. Wall of the central vein showed thickening . Focal infiltration of eosinophiles and lymphocytes were distributed at different places inside the lobule.

II. Family -- Trichuridae Railliet, 1915.

Genus -- Trichuris Roederer, 1761.

Species -- <u>Trichuris trichiura</u>
(Linnaeus, 1771) Stiles, 1901.

Host -- Domestic pigs.

Habitat -- Caecum and colon.

Locality -- Patna.

This parasite has been recorded from man and other primates. Baylis and Daubney (1922) recorded it from wild boar in Bihar. Maphlestone (1930), Alwar (1958) and Ahluwalia (1959) reported from domestic pigs in Bengal, Madras and U.P. respectively. In this survey it has been found fairly common (63.39%) in Chhotanagpur plateau as revealed by faecal examination, but was not common at Patna.

Male measures 30 to 40 mm. in length and 0.40 to 0.55 mm. in maximum thickness. Slender desophageal portion occupies two third and mask more of the whole length. Spicules measures 2 to 3 mm. long with pointed or rounded tips. Spicule sheath is quite variable in shape, sometimes cylindrical and sometimes expanded distally. This variability has also been mentioned by Baylis (1939). It is wholly or particially covered with spines.

The length of female varies from 35 to 44 mm. and maximum thickness from 0.6 to 0.7 mm. The vulva is near the junction of anterior and posterior portion. Eggs measure 45 to 55 X 20 to 24/u with polar caps on both sides.

III. Family -- Strongylidae Baird, 1853.

Genus -- Stephanurus Diesing, 1839.

Species -- Stephanurus dentatus Diesing, 1839.

Host -- Domestic pigs.

Habitat -- Peri-uretral fat, pelvis of kidney,
liver, lungs, abdominal and
thoracic cavities.

Locality -- Patna and Hazaribagh.

This 'kidney worm' of swine has also been reported from cattle and donkey. From domestic pigs in India it has been reported from Madras (Alwar, 1958) and U.P. (Rai & Ahluwalia, 1958; Ahluwalia, 1959). The incidence in this study was as high as 79.87%. The usual seat of predilection of this parasite is peri-uretral fat, where adult worms, usually in pairs, lie in fibrous cysts. On one occasion it was found in the pelvis of kidney. Stray adult and juvenile parasites were also found in lungs, abdominal and thoracic cavities. Juvenile forms were found in liver lying just below the liver capsule.

The adult worms are stout, the internal organs are partly visible through the cuticula. The male measures from 24 to 30 mm. long and 1.4 to 16 mm. thick. The buccal capsule is cup shaped with 6 teeth at its base. The rim of the capsule has six external cuticular thicknings of which dorsal and ventral are most prominent. Male bursa is poorly developed with rays as described by

previous authors. Spicules are equal, in some, subequal measuring from 0.7 to 0.9 mm. Vulva is close to the anus.

The juvenile forms recovered from liver resemble in mosphology to the adult. They measure 16 mm. to 23 mm. long.

Pathogenicity: Adult worms usually lie in pairs in firous cysts which is embedded in kidney fat or attached to uratral wall. The cysts communicate with the lumen of the ureter. Worms inside the cysts incite a purulent reaction and when the cysts are cut open a foul smelling sanguinous fluid surrounds the parasites.

Histologically inner wall of the cysts consisted of immature fibro blasts with infiltration of lymphocyts and eosinophiles. Gradually from inside outward more mature fibrous tissues are laid down incapsulating the whole mass.

In liver the worms were embedded beneath the capsule in a crumbly mass of necrotic tissue. Gross and histopathological changes were in confirmity with those described by Ahluwalia (1962) and other.

2. Genus -- Oesophagostonum Molin, 1861.

Molin, 1861.

Host -- Dombstic pigs.

Habitat -- Caecum and colon.

Locality -- Patna and Hazaribagh.

This species was first recorded from domestic pigs in India by Maplestone (1930). Subsequently it has been reported from Bengal (Thapar, 1956), Madras (Alwar, 1958) and U.P. (Rai & Ahluwalia, 1958; Ahluwalia, 1959). The incidence in this survey has been found to be 34.49%, generally in mixed infection with the other two species.

The males measure from 7.5 to 9 mm. and females from 9 to 12 mm. in length. The cephalic inflation is well developed, cervical grove extends some distance on to lateral surface. Lateral alae are absent. Buccal capsule has almost parallel sides. External leaf-crown has nine elements and internal eighteen elements. Cesophagus is club-shaped with no anterior swelling. Cervical papillae are towards posterior part of Cesophagus. Spicules 1.0 to 1.15 mm. long. Tail of the female is short, straight and tappers to a point, 0.23 to 0.29 mm. in length. Distance between vulva to anus is 0.23 to 25 mm. Vagina is directed in-wards and leads to pars ejactrix.

Aurir-Apicol or measure 0.8 to 6.0 cm. leng. Proude totl in

(ii) Species -- <u>Oesophagostcmum quadrispinulatum</u>

(Marcone, 1901) Alicata, 1935.

Synonym--O.longicaudum Goody, 1925.

Host -- Domestic pigs.

Habitat -- Caecum and colon.

Locality -- Patna and Hazaribagh.

the specific name O.longicaudum owing to its long female tail. Alicata (1935), however, brought to light the earlier description of the parasite by Marcone (1901) as O. quadrispinulatum. He, in accordance with the law of priority in zoological nomenclature, treated O.longicaudum as synonym. Maplestone (1931) recorded this parasite from pigs in Calcutta and gave a description. Ahluwalia (1959) reported the parasite from U.P. though Alwar (1958) while recording O.dentetum and O.brevicaudum failed to find this species in domestic pigs of Madras. During this survey incidence is 15.58% in 154 pigs examined. This was found in mixed infection with other two species.

This parasite resembles O.dentatum from which it is distinguished on the character of head, the character of buccal capsule, oesophageal swelling and long female tail.

Males measure from 7.6 to 8.5 & female 8.4 to 9.6 mm. The buccal capsule is broader posteriorly than antertorly. Spicules measure 0.8 to 0.9 mm. long. Female tail is markedly long tapering g to a point. The distance between anus and the tip of the tail is 0.35 to 0.41 mm.

(iii) Species -- <u>Oesophagostomum brevicaudum</u>
Schwartz and Alicata, 1930.

Host -- Demestic pigs.

Habitat -- Caecum and colon.

Locality -- Patna and Hazaribagh.

Maplestone (1930) recorded this parasite

(Cesophagostomum suis) as the commonest among pigs
examined at Calcutta, though Alwar (1958) in Madras
recorded this species to be less common than O.dentatum.
Ahluwalia (1959) reported it from the domestic pig in

U.P. In the present study the incidence is 31.17%
which is higher than that of O. quadrispinulatum and
slightly lower than O. dentatum.

O. dentatum. Males measure 6.8 to 8.4 mm. and females 7.6 to 9 mm. Buccal capsule is short. External leaf crown contains 14 to 16 elements, the internal 28 to 32 number. Bursal rays are mmx similar to 0. dentatum. Spicules are equal ranging from 1 to 2 mm. The female tail is short, bent dorsally and measures 0.25 to 0.35 mm.

IV. Family -- Metastrongylidae Leiper, 1908.

Genus -- Metastrongylus Molin, 1961.

Species -- M. apri (Gmelin, 1790)

Vostokov, 1905.

Host - Synonym - M. elongatus

(Dujardin, 1845) Railliet & Henry,
-- Domestic pigs. 1911.

Habitat -- Bronchus and Bronchiole.

Locality -- Patna and Hazaribagh.

Host

Baylis and Danbney (1923) recorded frangmentary material of this species from the bronchi of a pig in the collection of Zoological Survey of India; but it was uncertain whether the specimens were of Indian origin (Baylis, 1936). Bhalarao (1935) refers to its occurrence in pigs at Madras, while Thapar (1956) and Alwar (1958) recorded it from Calcutta and Madras respectively. In this survey it was encountered in only 3 of the 154 pigs examined from plain area of Bihar, but faecal examination at Hazaribagh revealed its occurrence in 23.21% of pigs.

There exists difference of opinion among different authors on the nomenclature of this species. Some of the authors refer to this species as Metastrongylus apri taking M.elongatus as its synonym; while others refer it the other way round. Daugherty (1944) has critically reviewed the genus Metastrongylus tracing the history of different species described under this genus and their nomenclature. According to him, Gmelin (1790) employed the

specific name Ascaris apri exclusively for this swine lung worm. Vostokov (1905) first proposed the genus Metastrongylus and designated this species as type-species of the genus and also described a new species M. Railliet & pudendotectus./Henry (1907) accepted M. apri, but in his later publication in 1911 adopted the name M.elongatus in place of M.apri without assigning any reason for doing so.Finally Daugherty (loc.cit.) pointed out that the use of M.elongatus as the type-species of Metastrongylus is not justifiable on the basis of priority. The tauthor also agree with him in retaining M.apri. The third species of this genus M.salmi was described by Gedoelst, 1923.

Daugherity (loc.cit.) has tabulate the main differential character of the three species.

Males measure 18 to 22 mm. and females upto 55 mm. in length. Club shaped oesophagus is 0.5 to 0.6 mm. in length. The male bursa is small, rays reduced or fused except large antero-lateral. The spicules are slender measuring 2.5 to 3.5 mm. and terminate in a single hook. Genital cone is strongly developed & gubernaculum absent.

The female tail is bent ventrally, measuring 0.09 mm. in length. Vagina is 2 mm. long and vulva of cloaca.

Pre-vulvular swelling is present. The eggs measure 50 to 55/u x 38/u and are embryonated.

Pathology: The pathology of experimental and natural infection of Metastrongylus spp. in pigs have been studied in Britain (Danh, 1953 & Machenze, 1958).

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Section of pig's lone infected with longwords. The characteristic over consolidation is flathed by highly enghysemblone cono.(H.S. 100 X.).

FIGURE ND. 181

Section of a brosoims of pis costs to inverse and the section of epithelium at certain piscos and limitalization in parthropolar region.

FISCRE NO. 19:

Contion of a broading of pin curious.

Tensie lunguage and sucond discharge continuing and a lunguage process of the pinter distribution of the pinter distribution are dean. (N.E. 1807).

Grossly the lungs showed yellowish white prominent emphysematous areas distributed mostly in diaphragmatic lobe. In a heavy infection recorded at Gauriakarma, these areas extended to the lung surface. The zones of emphysema and consolidation showed lobular distribution indicating blockage of the corresponding bronchi or bronchioles with the worms and the exudate. After cutting open the bronchi, worms were found embedded in the white fronthy muccus exudate.

Histopathology:-

Histological appearance corresponded to the gross changes. Worms were found embedded with exudate in the bronchi and bronchioles and areas of emphysema and consolidation were sharply demarcated. In the bronchi the parasites are surrounded by exudate of fibrinous character containing eosinophiles neutrophiles and mononuclear cells. The bronchial epithelium showed denudation at certain places and marked increase in the secreting cells at the other. The lamina propria displayed dense cellular infiltration. Lymphoid hyperplasia was evident in peri bronchial and bronchiolar connective tissue together with other cellular infiltrations at different sites.

The vesicular emphysema showed lobular distribution with consolidation of adjacent lobule. Alvioli showed extreme dilatation with breakage of its wall, the latter showing at places different degrees of cellular infiltration with eosinophiles and round cells.

V. Family -- Spiruridae Cerley, 1885.

1. Genus -- Ascarons v. Beneden, 1873.

Species -- A. strongylina (Rudolphi, 1819)
Alicata and McIntosh, 1933.

Host -- Domestic pigs.

Habitat -- Stomach.

Locality -- Patna. and Hazaribagh.

In India this species has been reported from Bengal (Maplestone, 1930; Thapar, 1956), Madras (Alwar, 1958) and U.P. (Rai & Ahluwalia, 1958; Ahluwalia, 1959). In the present study the incidence is 56.49%.

Baylis (1939) has briefly described Ascorps dentata (v. Linstow, 1904) Alicata and McIntosh, 1937 and separated it from A. strongylina mainly on the basis of size (male upto 35 mm. and female upto 55 mm.). The present specimens fall within the range given for A. strongylina.

The males measure from 9 to 13 mm. and females 16 to 20 mm. long. The pharynx in 0.08 to 0.09 mm. long and its wall has triple spiral thickening. Cervical alae is asymetrical on the left side only. The tail end of the male has asymetrical caudal alae, right one is widerthan left. There are 4 pairs of precloacal and one pair postcloacal pedunculated pepillae, placed asymetrically. Five pairs of sessile subventral papillae are present. Spicules are unequal, left measuring 12 to 2.6 mm. and right .42 to .5 mm. long. Tail end of female is conical .2 to 2.5 mm. long. Eggs are oval, embryonated & measure 35 to 38 X 20/1°

2. Genus -- Physocephalus Diesing, 1861.

Species -- P. sexalatus (Molin, 1860)
Diesing, 1861.

Host -- Domestic pigs.

Habitat -- Stomach.

Locality -- Patna and Hazaribagh.

This parasite has been recorded from Indian pigs by Maplestone (1930) in Bengal, Alwar (1958) in Madras, Rai and Ahluwalia (1958) and Ahluwalia (1959) in U.P.

Its incidence in this study was 44.15%, but the intensity in infection was lower/comparision to A. strongyling.

The males measure from 7 to 11 mm. and females 14 to 19 mm. The cuticle in the region of pharynx is slightly inflated, with two posterior pocket like folds laterally. The three lateral alae on each side begin just behind these felds. Pharynx measures 0.24 to 0.28 X 0.055 mm. Its wall has single spiral thickening with 23 to 24 turns which forms complete rings in the middle.

Male caudal end is spirally coiled. Caudal alae are slightly ssymetrical, right being a little longer. Spicules are unequal longer measuring 1.9 to 2.2mm. and smaller 0.3 to 0.4 mm. There are 4 pairs of pre-anal pedunculated papillae and 4 pairs of sessile sub-ventral papillae. The tail end of the female is from 0.11 to 0.13 mm. long and is suddenly constricted about 0.35 mm. from the anus, the tip being bent ventrally. Eggs are embrynated measuring 39 to 44 X 24/4.

3. Genus -- Simondsia Cobbold, 1864.

Species -- Simondsia paradoxa Cobbold, 1864.

Host -- Domestic pigs.

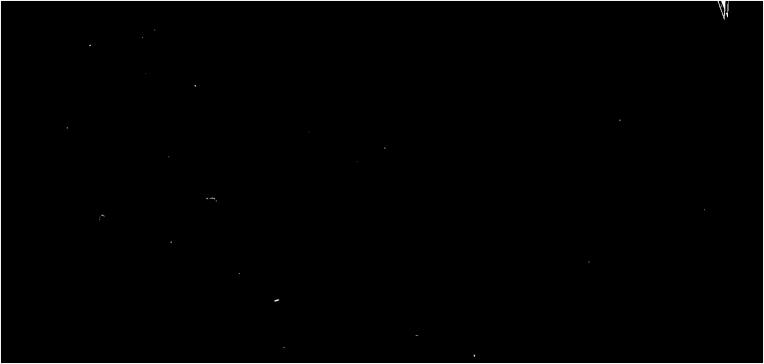
Habitat -- Stomach.

Locality -- Patna and Hazaribagh.

In India Ramanujachari and Alwar (1953) for the first time recorded this species from Madras and gave a redescription of this parasite. Ahluwalia (1960) studied the material from U.P. and gave a brief account of the anatomy and described the important pathological changes. He also described the morphology of 4th stage larva. In this survey incidence of this parasite is 30.52%.

Males are found free on mucosa but mostly are embeded in fundic mucosal pits with both the ends projecting in the luman of the stomach. It measures 11 to 13 X 0.3 mm. in size, with coiled tail end. Buccal capsules has characteristic single spiral annular thickening. From its middle start, on each side, symetrical cervical alae. Tail end has symetrical caudal alae. There are 4 pairs of pre-anal and two pairs post-anal symetrical pedunculated papilae.

Female of this parasite is a classical example of sexual dimorphism in nematodes. It has a large globuler body with small sacculations of the cuticle on the surface which give it a mulberry like appearance and a slender Cephalic region which proves its nematodal origin.



Cephalic portion measures 6 to 8 mm. in length and the diameter of spheroial portion is 3 to 4 mm. The vulva opens in slender region 1.6 to 2 mm. from anterior extremity. The uteri, oviducts and overies are complicatedly coiled in the enlarged spheroidal portion with intestine also interwined between them. Eggs are embryonated, elliplical 0.02 X 0.01 mm. in size.

Pathology: Fundus region of the stomach was covered with a layer of thick tenacious mucous. The mucosal pits containing projecting portion of the worm had thickened wall which gave this portion and indurated feeling.

Congestion at different places was marked. Pea sized submucosal hard cysts containing the globular portion of the female stood out on the surface prominently. When pressed or cut open a thick creamy pus oozes out.

Histopathology: The embedded portion of the male and the protruding portion of female were surrounded by infiltration of lymphocytes and eosinophiles. In the vicinity, laying down of fibrous tissues were seen. The globular portion of the female was seen surrounded by purulent exudative material comprising of neutrophiles, eosinophiles, lymphocytes & macrophages. This was surrounded by fibrous tissue. The glandular cells showed at certain the places atrophy and at/other cells were engorged with mucin secretion. Cellular infiltrations were also present in lamina propria, Congestion was evident in capillaries. Thus the picture presented is that of subacute to chromic catarrhal & at places purulent & at the other hypertrophic gastritis.

PROTOZOA

1. COCCIDIA AND COCCIDIOSIS.

Rivolta (1877) was first to report swine coccidiosis.

He attributed severe enteritis to E. zurnii which was
found epizootic among pigs. (Nevicky, 1945). Biester and

Murray (1929) pointed out that the literature dealing with
coccidiosis in swine prior to 1929 is of interest notwith—
standing the inadequate discription and confusion prevailing
with respect to classification. The first accurate
description of the pig coccidium was given by Douwes in
his Inaugural Dissertation (1921). He named it Eineria de
Blicki, which was later corrected to E. deblicki. He
believed that a large and small variety occurred. He
assigned no name to the larger variety. According to Biester
and Murray (loc.cit.), E. suis described by Noller (1921)
and E. brumpti described by Cauchmez (1921) are taken as
synonyms on the basis of priority.

Henry (1931) found that pigs at Kansas harboured, in addition to E. debliecki, other coccidia hitherto undescribed and named them E. scabra, E. perminuta and E. spinosa. The occurrence of these species have been confirmed by workers in other countries.

The fifth and sixth species of <u>Eimeria</u> genus, <u>E.</u> scrofae and <u>E. polita</u> were described respectively by Gallivalerio, 1935 from <u>Spitzerland</u> and <u>Pellerdy</u> (1949)

from Hungry. The coccidia of the genus <u>Isospora</u>, <u>Isospora</u> suis was described by Biester and Murray (1934).

In India Gill (1960) reported 6 species of coccidia viz. E. scabra, E. perminuta, E. polita, E. spinosa, E. debliecki and I. suis, from 20 pigs examined at Izatnagar. He finds justification for splitting E. scabra into two varieties viz. E. scabra var scabra and E. scabra var ellipsoidalis.

In the present work the incidence of coccidia was found to be 57% in deshi pigs, 47.4% in deshi pigs examined postmortem and 42.36% in Yorkshire pigs at Gauriakarma. Infection was not found to be very heavy. Out of positive samples for coccidia, 30 samples were randomly selected and sporulated for specific identification. The specific identification was based on the following morphological characters.

- (1) Shape and size of the cocysts.
- (2) Character of the occyst wall.
- (3) Micropyle-presence of absence.
- (4) Occyst polar granule -- presence or absence.
- (5) Gocystic residuum-presence or absence.
- (6) Sporocystic residuum-presence or absence.
- (7) Stieda body-presence or absence.

Three species of <u>Eimeria</u> viz. <u>Eimeria scabra</u>,

<u>E. debliecki</u> and <u>E. perminuta</u> were identified in 30

samples. Most of the pigs were found to carry multiple infection with two or three species. <u>E. scabra</u> was found

to be the commonest. The presence of coccidia was not found to be associated with any clinical symptom nor was any gross pathology observed in pigs examined postmortem, whose faeces showed the presence of coccidia. This might have been due to the fact that only adult pigs were examined, which are known to attain partical immunity after experience of infection in young age. Biester and Schwarte (1932) have produced complete immunity in pigs by feeding occysts for several days. E. deblicki is reported to be pathogenic in young pigs causing diarrhoea, dysentry and also mortality. The other two species encountered have not been found to be associated with pathogenicity. The lack of pathological findings in this survey may also be due to the non-pathogenicity these parasites.

The description of the species studied are given as follows:-

(i) Eimeria debliecki Douwes, 1921.

The occysts were ovoid or spherical in shape. The size was variable measuring from 16 to 28/u by 14-19/u. The smooth and colourless occyst wall was composed of two leyers usually 1 to 1.5/u thick. The micropyle was absent. The occyst polar gramule was also not observed. The occystic residual body was absent, but sporceystic residual body present. The sporceysts were ellipsoidal or ovoid measuring 14 to 16/u by 6 to 8/u. Stieda body

was present. In unsporulated cocyst the zygote was found practically filling the cocyst, sporulation at room temperature lab. atmospheric condition was complete after 9 to 10 days.

(ii) Eimeria perminuta Henry, 1931.

This species was found to be the second in order of prevalence after <u>E. scabra</u>. The size was distinctly smaller. The occysts are spherical or ellipsoidal in shape. The size varied from 12 to 15 by 10 to 13/u. The occyst wall was rough, taking an yellowish tinge.

Micropyle was absent. Occyst polar granule was present. Zygote practically fills the unsporulated occyst.

Sporulation was complete by 9 to 10 days.

(iii) Eimeria scabra Henry, 1931.

The occysts were oval or ellipsoidal in shape
measuring 24 to 32 by 18 to 25/4. Thus it was comparatively
larger than previously described two species. The occyst
wall was brown, rough and 1.5 to 2/4 thick, being
thinner at the narrower end. The roughness of the wall
in some of the occyst was not evident. Micropyle is
distinctly present, but it was not mentioned by Henry
(1931) though according to Pellerdy (1949) it was
present. An occystic polar granule is seen but there is
no occystic residual body. The sporocysts are
ellipsoidal, 15 to 18 by 6/4 and have sporocyst residuum.
The sporulation in lab. conditions is complete by 10-11 days.

2. Balantidium coli (Malmstem, 1857) Stein, 1863.

This parasite was first discovered by Malmstem (1857) from two dysentry patients in Stockholm, who called it Parameecium coli (?). It was placed in the genus Balantidium by Stein (1863). In India the first human case was recoverded by Sinton (1923). According to Wenyon (1926) Balantidium was first observed in pigs by Leuckart (1861 a, 1863) which was confirmed by many other observers. According to Levine (1961) B. coli is extremely common in swine having been reported in 21 to 100% of them in various surveys but the low figures may reflect the examination technique rather than the true incidence. There seems to be no published record on the extent of balantidial infection in swine in India except the comment of Knowles (1928) that the pig and monkeys in India are very commonly parasitised with Balantidium. In India it has also been reported in cattle by Biswas and Kannungo (1959) and Patnaik (1960) from Orissa, who found it associated with chronic dysentry.

According to Wenyon (loc. cit.) the experimental evidence of Brumpt (1909) and Walker (1913) and other epidemiological evidences have proved the identity of swine and human Balantidia. McDonald (1922) showed that two species of Balantidium occurred in swine, B. coli and B. suis. The latter has more slender body and straight macronucleus. B. coli of pig is transmissible

to man and vice versa but B. suis is specific to the pig. Hegner (1934) studied Balantidium species from different hosts and has listed certain characteristics for specific identification based mainly on size and shape of body and macronucleus. He concluded that Balantidium from the domestic pigs may belong to two species, B. coli and B. suis; but conclusive evidences are still lacking. Clone culture studies by Levine(1940), Lemy Roux (1950) and cytological and cultural studies of Auerbach (1953) go to show (quoted by Levine, 1961) that B. coli and B. suis are not different species, but the variation in morphology is due to different physiological state of the parasite. Levine (1961) has regarded B. suis as synonym of B. coli.

Balantidium in pigs, unlike those of human and other primates, are regarded to be non-pathogenic, but its association with pathogenic effects have been occasionally recorded (Beck at al., 1943; Ray, 1937).

In the present study the parasite was found to be very common, 72% in 100 deshi pigs, 68.88% in deshi pigs examined postmortem and 38.4% in 336 Yorkshire pigs examined at Gauriakarma. Its presence in faeces was not found to be associated with any clinical symptom, nor any gross pathology was observed in pigs examined postmortem. Histopathology also failed to show any tissue phase of the parasite in the portions of caecum and colon.

The morphology of unstained and stained specimens was studied. As pointed out by Hegner (loc. cit.) 40 trophozoites not undergoing binary fision, from 4 pigs were measured with the help of occular and stage micrometers. The length varied from 64 to 88/u and breadth from 48 to 66/u. The length breadth ratio varied from 1:25 to 1:48. The body ratio given by Hegner was for coli-type 1:20 and for suis-type 1:42. But in this study specimens with intermediate ratio were also encountered. Thus the present specimens are identified as B. coli only.

The trophozoites were ovoid and covered with many longitudinal rows of cilia. There was small peristome near the anterior end lined with coarser cilia. Cytostome and cytopharynx were located at the end of peristome. The cytopyge is near posterior end; one contractile vacuole was terminal and the other near the centre of the body. There were many food vacuoles containing cell fragments. Macronucleus was sausage or kidney shaped, 22 to 34 X 9 to 12/4. The micronucleus was small and vesicular. The cysts were spherical to ovoid and measure 34 to 46/4 in diameter.

DISCUSSION.

It is apparent from the review of informations available on the parasitic infections of swine in India that the work in this country has mostly been confined to the taxonomic aspects only. The informations on regional prevalence of the parasites with correct assessment of its epidemiology and pathogenesis, which are the pre-requisites for designing control measures in Veterinary and Medical fields, are rather meagre. This survey, which covers unexplored areas of Bihar State in respect of swine parasites, has revealed, in addition to recording on the occurrence of parasites belonging to 21 species, some other interesting facts regarding geographical distribution, predilection site, pathogenic effects & some other implications of these parasites, which can fruitfully be discussed in the light of present day knowledge.

In this study striking differences in incidence have been met with in respect of certain parasites from the records of previous authors in this country.

Stephanurus dentatus Diesing, 1839 was not recorded in his survey by Maplestone (1930) in Bengal and was met with by Alwar (1958) in Madras in only 4% of 50 pigs examined, though Ahluwalia (log. cit.) found it common in U.P. without indicating percentage of infection, In the present study it was found to be very

Opistherchis noverca Brau, 1903 has not been reported from any other part of the country except Bengal, where Bhalerao (loc. cit.) recorded the incidence only in 10% of the 49 pigs examined and mentioned liver and intestine as its habitat. Whereas in the present study the incidence of this parasite has been found to be very high (69.48%) inhabiting pancreas only. The pancreas were examined within 10-30 minutes after thaughter and host tissue reaction was noticed in each case. So, the postmortem migration is ruled out.

Finally, whether the absence or lower incidence of this parasite in certain areas is attributable to any geographical, climatic or other biological factors or to the limited nature of the survey remains to be determined by undertaking works on larger scale.

Higher incidence of Metastrongylus apri

(Gmelin, 1790) and Trichuris trichiura recorded from the

pigs maintained at Gauriakarma as compared to deshi pigs

of the plain area may also be attributed to the climatic

and other biological factors. M. apri requires an

earthworm as intermediate host, whose relative

prevalence in the climate of Chhotanagpur plateau may be

a determining factor. Similarly, epidemiological evidence

has shown that a high incidence of Trichuris infection

is associated with abundance of moisture in the soil, due either to heavy and well distributed rainfall or dense shade. This is in consonance with the comparatively high rainfall and thick vegetation of Chhotanagpur plateau in comparison to that of the Gangetic plains.

High incidence of multiple infections also pose a serious problem. Spindler (1951) rightly concluded that each species of helminth in swine damages its host, and that the natural mixed infection can mean the difference between profit and loss in swine production. More than one helminth and protozog have been found to infect the same organ of a single host. This is a point to be considered in adopting control measures. A drug effective on one group of parasites may not be effective on the other causing a selective preponderance of the other group. In addition multiple infections of the same organ of an individual host may enhance the pathogenicity caused by any single type of helminth or protozoa. Liver is an outstanding example which is attached by the migrating larvae of both Stephanurus dentatus and Ascaris lumbricoides var suum.

Several parasites of zoonotic importance have been recorded and these have great epidemiological significance from the public health point of view.

Among these are (1) Artyfechinostomum sufrartyfex

(2) Opisthorchis noverca (3) Gastrodiscoides hominis

- (4) Fascilopsis buski, (5) Cysticercus cellulose,
- (6) Echinococcus eysts, (7) Trichuris trichiura,
- (8) Ascaris lumbricoides (?) and (9) Balantidium coli. All have been recorded to occur in human population in India. Some of them, for example B. coli, is regarded to be non-pathogenic to swine host, but causes diarrhoea and dysentry in man. Thus swine acts as a reservoir host, donating the infective material to persons coming in its close contact. This is true with other parasites also, enumerated above. In country-side, pigs are maintained by poor people in most unhygienic condition and they also share the same environement exposing themselves to the danger of infection. Even in case of human population the prevalence of these parasites have not been assessed fully excepting the work of Buckley (1939) in Assam and eccasional case records by other authors.

The pathology studied for certain worms point to the damage sustained by the pigs in this State. Pathology of <u>O. noverca</u> in pancreas, described for the first time and its higher incidence in this State deserves consideration in the control of helminthissis. Similar is the case with the pathogenicity of lung-worms described here and its higher incidence in the Farm condition of Chhotanagpur plateau. <u>S. dentatus, A. lumbricoides</u> var suum & <u>S. paradoxa</u> have been found to be associated with pathologic conditions in natural infections.

CHAPTERII DEVELOPMENT AND PATHOGENICITY OF ASCARIS LUMBRICOIDES VAR. SUUM IN DIFFERENT ANIMALS.

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Stewart (1916, 1917, 1918, 1919, 1921) worked out the llife history of Ascaris lumbricoides and showed that a liver-lung migration occurred in rats and mice. Ransom and Foster (1919, 1920) Ransom and Cram (1921), Payne (1925), Robert (1935) and Sprent (1952) carrying experiments on pigs, sheep, goats, rabbit, guinea-pigs, rats and mice demonstrated that liver-lung-tracheal migration occurred in all the animals. Ransom and Foster (loc. cit) recovered from the intestine of a young goat and a lamb immature worms that had developed beyond the stages previously obtained from rats, mice, guinea-pig or rabbits. Ransom (1922) concluded that the development, at least in the case of lamb, was very slow and apparently the worms never reached fertile maturity and commented that the so called Ascaris ovis in sheep was nothing else than Ascaris lumbricoides.

Ascaris lumbricoides in pigs at the age of 10 months.

But the difficulty in infecting swine with its own ascarids was experienced by many workers. De Boer (1935) found that repeated doses brought more consistent results. Clapham (1936) while infecting swine experimentally concluded that the known resistance of swine to experimental infection was slight and of temporary nature. Lindquist (1959) also expressed the difficulty in establishing infection in swine with its own ascarids.

Nichols (1956) studied the morphology of Ascaris

Lumbricoides larvae recovered from organs and in tissue
sections of white mice and has given an illustrated
account. Kelley et al (1957) studied the larval growth
of swine ascarids in pigs and found that the larvae
from pigs were generally larger than those from rabbits,
guinea-pigs and mice.

Mottoff and Wassileff (1956) found A. lumbricoides in Bulgarian sheeps and regarded the previously described A. ovis as A. lumbricoides. Bhalerao (1935) also lists sheep as host of A. lumbricoides. Vassilev (1960) infected 5 kids with ova from swine ascarids and found that worms reached sexual maturity, though later than in pigs, but failed to infect adult goats. Berger et al (1961) showed for the first time the development of A. lumbricoides var. suum in rabbits upto sexual maturity after experimental infection.

Fallis (1948) and Voorhorst (1957) found
eosinophilia respectively in guinea-pig and mice
experimentally infected with Ascaris while Zedulka (1960)
showed that interstitical chronic eosinophilic hepatitis
was associated with migratory ascarid larvae in pigs
and in lungs it exacerbated chronic bronche-pneumonia.
Fitzerald (1960) infected lambs experimentally with
Ascaris lumbricoides var. suum and recorded similar
migration and larval development as in other experimental

animals. He did not find development to the adult stage. Eosinophilia was the only change in blood picture.

From the above review it transpires that the host range of Ascaris lumbricoides var. suum, in which its development to the adult stage can take place, has got conflicting reports. The pathogenesis and other implications other farm animals of economic importance need more ellucidation.

The present study was undertaken to find out the development of swine ascarids in local breeds of sheep, goats, pigs and some laboratory animals and to study the haemotological and pathological changes produced.

MATERIAL & ND METHODS

ascarids collected from a local slaughter house and were kept in physiological saline solution to remove the debris and sticky material which causes clumping in aqueous media. After 3 days, eggs were concentrated by sedimentation and cultured in two sets of Petri dishes, one containing 1% formalin and the other 1% Potassium dichromate solution in tap water. This was kept at room temperature varying from 23°C to 35°C and frequently (once or twice a day) agitated for oxygenation. Embryonic movement started after 9 to 10 days and fully formed larvae appeared by 17 to 19 days. Infections to experimental animals were given after 40 days of culture (Stoll, 1933).

For giving infection, the materials from different Petri dishes were mixed together, concentrated and washed several times by repeated (4 to 5 times) centrifugal-sedimentation. These eggs were stored in tap water for feeding to the experimental animals. Before giving infection eggs were counted by dilution method. From an even suspension of eggs in tap water, 0.02 cc. was removed with the help of a micropipette (0.1 cc.) on to a slide and counted under the microscope. The average of ten such samplings was multiplied by 50, which gave the number of eggs in 1 cc. of the suspension. The eggs in

suspension were administered to the animals with the help of pipette.

Rats and guinea-pigs nearly 15 to 20 days old,
lambs and kids nearly 10 to 15 days old, month old
rabbits and month old piglets purchased from a local
supplier were thus exposed. Lambs and kids were kept on
their mother's milk only and These animals were kept
on concrete floored house. Piglets were fed concentrate
diet of grains. Faecal samples from all these animals
were examined with negative results for 6 days.

Doses and period of observation were adjusted as detailed in the Table VII. Animals intended to be sacrificed on the 5th and 10th days received relatively higher infective doses. Those, which were to be left for longer period to see the development of the parasite to adult stage, received relatively smaller doses.

Single dose infection was given to all the animals.

Faecal samples removed from the rectum of animals of the latter group were examined at 5 days' interval after one month of exposure to infection toodetect the presence of eggs.

Clinical symptoms shown were also noted. Animals sacrificed on the 5th and 9th days were searched for larvae in liver, lungs, kidney, spleen, and mesenteric glands. In heavy infection larvae were detectable in press preparation.

84

TABLE NO. VII.

Table showing the infecting dose of Ascaris lumbricoides ova with the period of observation in different animals.

-		8				
1	Period lafter which killed	days	4	0	99	82
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1 6	reriod fafter which	1000	4	0	79	82
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Res	No. of Ferior embryolafter nated Which eggs [kille	Thou-	10	•	-	10
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8	Mo. One on the one of the order	Thou-	80	20	10	00
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	0 50	daysi sands	80	20	10	10
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-	No.of Ferio embryojafter nated Which	da	4	(d1ed)	48 (d1ed)	64
	2 2 2	1 10	0		24	24
×		Thou-	138	120	es	CS
Indmo 1	No.			જ	10	4.
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Larvae from tissues were recovered by putting the minced or finely cut pieces of the organs in warm (40°C) physiological saline solution and incubating it for an hour. After this period the emulsion was poured into a cylinder for sedimentation. Two hours later the whole liquid was syphoned off except nearly 2C cc., which was centrifused lightly for further concentration of the larvae. Larvae were fixed in 70% alcohol. Measurements were taken of heat-killed larvae with the help of ocular and stage micrometers and morphological studies were made by immobilising them in egg albumen (Nichols loc. cit.), which was found to be more satisfactory in displying internal structures than by studying the alcohol-fixed larvae in glycerine jelly or by staining in acid fuchsion.

For Histological studies small pieces from lungs, liver and spleen were fixed in formal-saline or Bouin's fluid and standard procedure was followed for dehydration, clearing and embedding in paraffin. 5/4 thick sections were made and stained with Haematoxylin and Eosin.

Haematological studies were made only in sheep and goats. Total R.B.C., W.B.C., Haemoglobin estimation and differential count were made at approximately 5 days interval upto 15th days of infection. One kid and a lamb were kept as control for showing the normal variation.

OBSERVATIONS.

Liver and lungs of all the animals (rats, guinea-pigs, rabbits, sheep, goats and pigs) sacrificed on the 5th day of infection yielded fair number of larvae except white rat from which only few larvae were recovered. On the 10th day larvae were constantly recovered from lungs. The liver was found to be free,

Measurements of randomly selected ten larval specimens, collected on the 5th and 10th day of infection from each animal are given in table VIII.

TABLE NO. VIII.

Measurements of 10 larvae of A. lumbricoides var. suum recovered from liver and lungs of different animals on the 5th and 10th day of infection.

Sl. No.ă	Species of animal		5th day	Larvae 10th Laverage 1 1 1 1 1 1 1 1 1	the state of the s
1.	Pigs	498	439-563	1610	1430-1820 *
2.	Sheep	472	426-540	1508	1380-1730
3.	Goat	497	432-558	1585	1300-1740
4.	Rabbit	471	418-529	1508	1320-1720
5.	Guinea-pig	492	426-549	1522	1290-1720
6.	Rat	484	419-523	1440	1220-1620

^{*} Recovered on the 9th day.

Studies of the larvae showed no morphological difference assignable to the influence of particular host in which the development took place. The

FLATE IN. M: FLA. 30

totis are more became prost strong and site of the days of cabreometion.

FIGURE NO. 31:

Ascerds larves in lung of sheep (press properation).

FLAGRE NO. 38:

Ascerts larve recovered from lange

after 9 days of infertion.

A. Anterior end.

A. Fosterior end.

morphological details of larvae were in agreement with those given by Nichels (loc.cit.) for Ascaris lumbricoides except some dimensional variations. Difference in size of the larvae recovered from different host animals used did not show any marked significant difference.

Development to the adult stage:-

Faecal examination of all animals for ascarid ova were negetive except one pig which violed eggs on the 61st day of infection. When sacrificed on the 65th day, 6 females and 2 males were of swine ascarid were recovered. The other pig which died on the 48th day was not harbouring any mature or immature worm. From the rabbit which died on the 39th day, 2 males measuring 110 to 115 mm. and 4 females measuring 130-150 mm. were recovered from small intestine. Other animals sacrificed after 64 and 82 days of infection did not harbour any mature or immature worm in their intestines.

Clinical symptoms:-

In general animals receiving higher infective doses showed marked symptoms. In-difference to food and respiratory difficulty were symptoms shown by the animals, which started on the 6th to 7th day and became marked by 9th and 10th days. Rat comparatively showed little change. Lambs and kids developed marked

dysphoea. The latter was also pronounced in pigs. One pig after rise of temperature (105-106°F) succumbed on the 9th day. Rise of temperature was also observed in one kid. The animals became apparently normal by 12th to 13th day.

The results of haemotological findings are given in Table IX(a) and IX(b). The only significant increase is in the eosino phile, count and a slight decrease in neutrophils.

Gross Pathology:-

In animals sacrificed on the 5th day postinoculation the pathologic changes were mainly limited
to liver and lungs. Liver was found congested and
enlarged. Some haemorrhagic spots beneath the capsule
were seen in the liver of pig, kid and lamb. Lungs
showed petechial haemorrhages and oedema. On the tenth
day the changes in lungs were much pronounced.
Haemorrhagic spots were much increased particularly in
rabbits. The pigs which died on the 9th day showed
areas of consolidation indicating pneumonia. The lungs
of kid and lambs were highly congested and oedematous.
Echymotic haemorrhages were distributed generally on
the spices of lungs.

Histopathology: -

There is focal necrosis of liver. At places the necrosis is confined to the peripheral portion of the

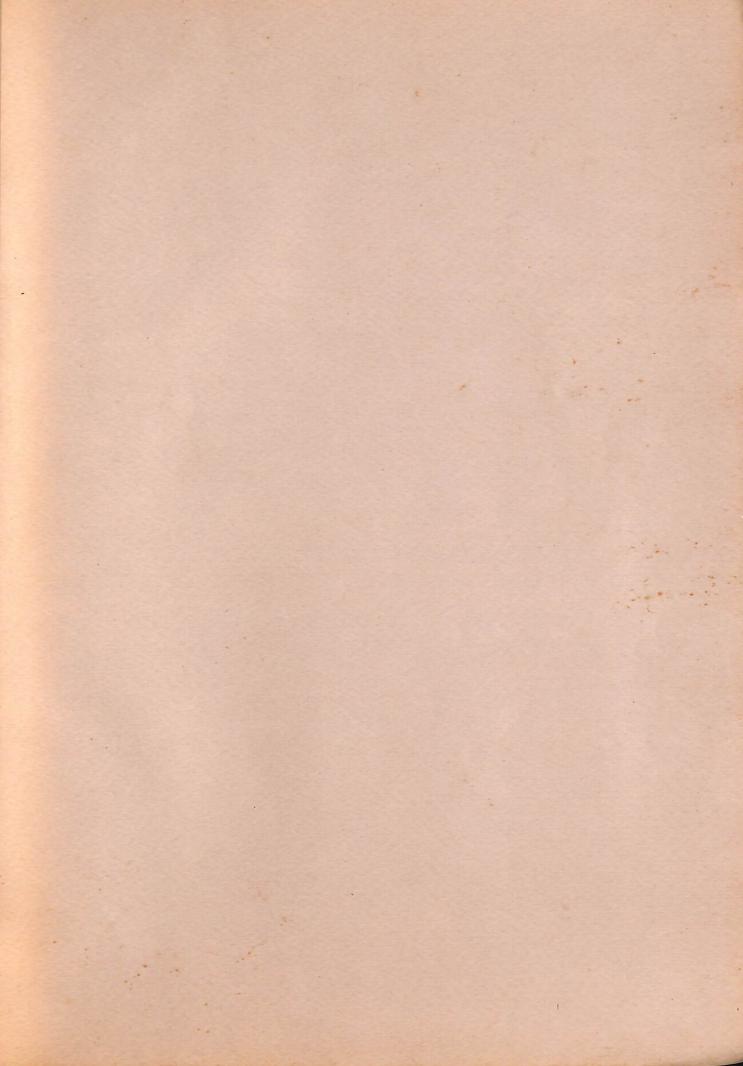


Table showing the haematological findings in sheep and goat infected with A. lumbricoides

	in 14th day	•		10.01	10.2	10.6		8	00.00	8.6	6.8	ALL PROPERTY.
SHS.	SHE SHEET SHEET SHEET		8.4	9.6	9.8	11.0 1		8.6	8.8	10.01	4.00	Andread of the Association of th
in	day I day	8.0	9.6	10.2	10.3	10.3 11	9.0	8.5	8.6	10.4 10	80	
Haemoglobin	None day kon Noefore K da Kinfec K	10.2	8,0	10.01	9.6	10.6 1	8.8	7.8	10.01	10.2 1	8.6	
300	14th		9	7.28 1	5.95	7.10 1		1	4.85	.75 1	5.91	
thousands	post rest rest		7.00 8-	6.90 7	6.10 5,	7.30 7.		3.85	5,75 4,	5,95 5	6.20 5	
in	y theor	5.75	7.30	7.80	06.3	7.20	5,85	4.65	4.90	8,10	5.85	at any other designation of the same
Total W.B.C.	Company and the Company of the Compa	5.20	6.25 9	7 .40 7	5.05	6.35 7	6.30	4.15	5.25	8.40 8	4.75	
-	4th	10	9	12,92 7	12,43 5	12.97 6	9	4	7 .32 5	8.74 8	9,84 4	
illions	h A d		11.94	13,18 12	12.23 12	13,52 12		10.20	6.52 7	8.65 8	10.32 9	
R.B.C. in millions	day of day	13.83 -	12.21 11	12,43 13	12,80 12	13,50 13	7,34	9,52 10	6.84	9 .27 8	9.94 10	
Total R.B.		15.52 13	11,83 12	12,93 12	13.20 12	14.67 13	8.06	9.52	7.74	9,46	10.39	
TI G	I the f		c)		4.	. 22		01	60	4.	٠ ن	
Anin	0	Goat No.	No.	No.	No.	No.	Sheep No. 1	No.	No.	No.	No.	

TABLE NO. IX(b).

Table showing Differencial Leucocytic count in sheep and goat infected with A. lumbricoides

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lobule and at the other it has involved middle and central portions as well. Most of the lobules are spared. At places there is localised infiltration consists mainly of eosinophile and lymphocytes and at some places polymorphs. The areas of infiltration are found in portal tract, round blood vessels and even in lobular area. Congestion is also evident. Degenerative changes are present. Some of the parenchymal cells are showing cloudy swelling and fatty changes. Histological changes were practically same in all the animals. Lungs: - Larval sections in lungs are found in different situations viz. alvioli, bronchioles and blood vessels. Blood vessels are markedly dilated and congested. There is haemorrhage in alvioli marked by the presence of pink staining red blood corpusles. The alvioli are also packed with eosinophile lymphocyte, macrophages and some polymorphs, presenting a picture of pneumonia. Bronchiolar and bronchial epithelium are desquamated with some metaplastic changes. At times it was difficult to recognise bronchiolar section due to loss of epithelium and metaplastic changes.

In sheep, gtats, pigs and also rats the congestion is less pronounced in comparision to rabbits and guineapigs. The alvioli contain inflammatory exudate of fibrinous material. The cellular portion consisting of R.B.C. lymphocytes, some eosinophiles and plasma cells. The desquammation of bronchioler epithelium and peri-bronchiolar infiltration are present.

DISCUSSION

The larvae of Ascaris lumbricoides var. suum were constantly recovered from liver and lungs of rats, guineapigs, rabbits, sheep, goats and pigs showing the migratory behavior in all the animals. The mean value for the larvae of swine was slightly bigger in comparison to those recovered from other animals, but on statistical analysis the size difference was not significant. But But it may be noted that the larvae measured from swine were only nine days old. Thus, the findings may be construed to agree with Kelley et al. (1957) who found that larvae were bigger in swine than in guineapig, mice and rabbit.

In establishing infection im different hosts, varied though migration in liver and lungs occurred in sheep and goats but mature or immature worms were recovered. This finding lends support to the observation of Fitzerald (1960) but is not conformity with those of Ransom and Foster (loc.cit). Mottoff and Wassileff (loc.cit.) and Vassilev (1960). This observation thus keeps sheep and goat in relation to swine ascarids in par with several other host like man, cattle, mice, rats and guineapig in which the larvae migrate through liver, lungs and intestine with eventual disappearance.

In pigs, which is the natural host, the infection could only be established in one, out of two pigs, though

larval migration was observed in the rest two sacrificed earlier on the 5th and 9th day. According to Lindquist (1959), in recent years several workers have met with great difficulty in infecting pigs with their own ascarids.

It was previously believed that rabbit fall in line with other lab. animals in which the larvae migrate through the liver and lungs and do not develop further in the intestine. But in this experiment one of two rabbits which died on the 39th day, six female and two male immature worms were recovered. This confirms the finding of Berger et al. (1961) who established potent infection in rabbits and found typical A. lumbricoides eggs in the faeces by the 46th day. But the specimens recovered in this experiment are immature. It may be noted that Berger et al. (loc.cit.) had also got immature specimens from infected rabbits in their experiments.

Pathogenicity

The danger inherent in close association of the pigs with other farm animals can well be imagined by the migratory behavior of <u>A.lumbricoides</u> var. <u>suum</u> in such a wide range of hosts with resulting damage in such vital organs like liver and lungs. Its pathogenicity in its normal host in pig is well studied and the parasite has been incriminated to inflict great loss on the pig industry (Spindler, 1947).

The onset of symptoms shown by all the animals coincided with the migration of larvae in the lungs. Dysphoea and other resperatory symptoms were observed in all the animals which was particularly marked in pigs.

There was no significant change in the haematological picture as regards total R.B.C., W.B.C. and haemoglobin content. But the eosinophilia showed a marked rise by the

also a drop in neutrophile count and in one animal it was as low as 18%. This eosinophilia and decline of neutrophile count were also observed by Fitzerald (loc.cit.) in lambs.

The pathologic changes were mainly found in liver and lungs. The so commonly described white spot or milk spot liver indicating the areas of fibrosis was not observed in animals killed on the 5th and 10th days. Though the congestion and distributed pale areas were present which indicated by the interval histological findings of congestion, degeneration and necrosis. The focal distribution of necrosis and infiltration indicates the place traversed by the larvae. The infiltration eosinophiles and polymorphs. These findings of pathological picture is in agreement with those given for lambs by Fitzerald (loc.cit.) and also Zendulka (1960).

Lungs showed grossly haemorrhagic areas, congestion, oedema and some cases consolidation. Histological picture were in agreement gross finding. Larvae were present in alvioli, blood vessels and bronchioles which conforms to the migratory rote taken by the larvae. Expensive haemorrhage in alvioli are present. The outstanding feature of the histological picture is extensive infiltration of lymphocyltes more so in the peribronchial and bronchiolar region together with some plasma cells and desquammation of the bronchial epathelium. These changes were more marked in kids, lambs and also pigs where as metaplastic changes were observed in bronchi of guineapig and rabbits.

Schwartz and Price (1929, 1931, 1932) experimentally infected swine with the larvae of Stephanurus dentatus by feeding and also applying the larvae on abraded skin and found that the larvae reached liver, stayed there for considerable length of time, grew in size and finally broke through the liver capsule reaching the kidney region, where they were found in cysts in uretral wall or in peri-renal fat. They also infected guinea-pigs, but could not recovered the worms from the renal region.

Spindler (1934 a,b) studied the biology and infectivity of S. dentatus and found that the larvae were very susceptible to low temperature, sunlight, drying and heat. He found that larvae penetrated swine skin only when soil or some substance was present on it.

Sensitivity of S. dentatus eggs and larvae to low temperature, desiccation, sunlight and high temperature has been noted by many other workers. Ikoma and Ito (1952) found that the eggs hatched in 22 hours at 30°C and high temperature was inimical to the larvae.

Tromba (1955) made a great contribution to the understanding of the biology of <u>S</u>. <u>dentatus</u> by experimentally infecting earthworm, <u>Eisenia feetida</u> with its infective larvae and noted its persistence in the earthworm for a long time. He further experimentally infected pigs by feeding the ground parasitised earthworms

and found 4th stage larvae and pathological
the liver. Later in 1958 he established pat
in 5 pigs by feeding parasitised earthworms
determined by the passage of eggs in the urine.

Batte, Harkena and Osborne (1960) found that the optimum temperature for egg hatching was 27.5°C and maximum and minimum temperatures for hatching were 37.5°C and 16.0°C respectively. They also infected and observed the persistance of S. dentatus larvae in S. foetida. Pigs were infected by feeding the parasitised earthworms.

Ahluwalia (1962) in India made some preliminary observations on hatching and development of larvae to the infective stage. Larvae hatched at room temperature in about 36 hours and become infective by the 5th day.

In this survey S. dentatus was found to be the most commonly prevalent parasite of pigs. Its high prevalence in the tropical climate of Bihar with a wide temperature range in face of the reported sensitivity of the eggs and larval stages to climatic factors like heat, temperature and sunlight, seems rather paradoxical. The present investigation was undertaken to find out the possible transport vector among the local annelids. Incidentally some observation on the effect of temperature on hatching of larvae and the period required to reach the infective third stage has been made.

MATERIALS AND METHODS

Eggs were obtained by chopping of the female worm in water to liberate eggs and also by washing the internal contents of the cysts which harboured the parasites. They were strained and washed 3 to 4 times in water by centrifugation to remove the debris. Freliminary observations on hatching time and time required for development of larvae to the infective third stage were made by putting the eggs in small Petri dishes with 3 mm. deep water and keeping them at from temperature varying between 23 to 35°C and at a constant temperature of 27°C maintained in the low temperature incubator. The choice of temperature for regular larvae culture was made on the basis of these observations particularly in relation to time required for the larvae to reach infective stage, lower percentage of mortality and survival for longer time. Culture of Larvae :-

Two methods were followed in larval culture at a constant temperature of 27°C.

(1) Water Charcoal culture: Large number of washed eggs were kept in separate Fetri dishes containing 3 mm. deep water and a small quantity of animal charcoal was added.

They were kept in low temperature incubator and covered partically with the lid to allow the passage of air.

Petri dishes were frequently (once or twice a day) shaken and examined for development of the larvae.

Distilled water was added to make up the loss due to

evaporation.

(2) Culture in sheep faeces :- Modified method of Whitlock (1956) was followed according to local conveniences. Fresh sheep pellets were crushed and made helminthologically sterile by putting them in a wide mouth glass vial and heating for 15 minutes in a water bath. Sterile sand and animal charcoal were mixed and a pad of thickness of this material was made in the bottom of the vial. Distilled water was added to moisten it and the washed eggs were spread. 0.2% sodium bicarbonate was put in the bottom to reduce the development of mold. The vials were loosely covered with lid. The latter was frequently removed for aeration and a small quantity of distilled water was added to make up the loss due to evaporation. The infective larvae were found by the 5th and 6th day in the water of condensation on the sides of the vials. They were removed with the help of pipette, by putting a small quantity of water on the sides and sucking them back. These larvae were obtained in a clean state. On the 7th day the whole culture was Baermanned and rest of the infective larvae were recovered.

Infection to the earthworms:-

Earthworms were collected in large number from compost heaps. In the laboratory they were maintained in big glass trough containing moist earth. A piece of canvas was spread over the culture and water was frequently sprinkled to keep it moist.

Earthworms collected were of two types. Both were sent for the specific identification to the Director, Zoological Survey of India, Calcutta. Gaztiman One of them, which was comparatively larger having dark colour, was identified as <u>Eutypheus waltoni</u>. The other one could not be identified, but probably it belonged to <u>Pheretima</u> genus. These two vaerities are very commonly encountered in this state.

The infection to the earthworm was given in staining dishes. A bed of mixture containing autoclaved earth and compost was made on the bottom and moistened with water. To this was added infective third stage larvae obtained from water charcoal culture and those obtained by Baerman method from faecal culture. The earthworms were then put in the dishes, covered with a piece of moist convas and finally with a lid. The convas was frequently moistened with water.

The earthworms for examination were removed from the dishes, anaesthetised in 20% alcohol and dissected on the waxed tray giving a mid-dorsal incision. The whole intestine was removed and examined in small Petri dishes containing tap water under dissecting microscope. Portions of the body wall were pressed between two glass pieces and examined for larvae. Larvae were studied in the living state or by killing them on slide with gentle heat.

Neutral red was used for intra-vital staining. Rest of the of the larvae were preserved in hot 70% alcohol. These alcohol fixed larvae were stained with said fuchsin dissolved in lactophenol and then mounted in clear lactophenol for study.

Infection with infective larvae obtained from culture on the 5th and 6th day were given to 3 guineapigs and two rabbits in the doses 800 and 1000 respectively. The larvae removed from the wall of the culture vial were counted by dilution method. 0.25 cc. of an even suspension of larvae was transferred in a an excavated glass block and the number of larvae in them were counted. Average of of ten such sampling was multiplied by 20 to give the number of larvae in 1 cc. of suspension. Larvae were concentrated before feeding and were fed with the help of pipette.

Lacroni proprietal also as block to \$5 and some of their

OBSERVATIONS.

Eggs cultured in water at room temperature varying between 23 to 25°C hatched in about 36 hours. Those cultured at a constant temperature of 27°C also took practically the same time. The larvae reached the infective third or 6th day. Thus, these two sets of temperatures were not found to influence markedly the time taken by the eggs to hatch and the larvae to reach the infective third stage. But the difference was marked in respect of percentage mortality and survival time of the larvae cultured in two sets of temperatures. At room temperature larvae were found dead at different stages of their development. By the twelth day most of the larvae lost motility. In the cultures kept at 27 C larval mortality was far less. They were very active and survived for a longer period of time. Water charcoal and faecal cultures kept at 27°C gave a good harvest of infective larvae.

Thirty five earthworms each of <u>Eutypheus waltoni</u> and <u>Pheretima</u> sp. (?) were examined from 1 to 40 days after exposure to infection. All thirty five <u>E. waltoni</u> examined harboured a large number of larvae in the gut. They were distributed from anus to oesophagus showing no special preference for any particular site. The maximum number of larvae recovered was as high as 48 and none of them harboured less than twelve larvae. These larvae were very active. At room temperature they survived upto 10 days.

On the contrary the other earthworm, Pheritima sp.(?)
was
was found to take up very light infection. Out of 35
examined, larvae were recovered only from 26. Moreover, on
no occasion larvae were obtained from morethan ten in
number.

This experiment was repeated with 20 earthworms each of E. waltoni and Pheretima sp. (?) and similar results were obtained as in the previous one.

Morphologically, larvae recovered from earthworms and the infective larvae obtained from fulture were identical except that those recovered from earthworms had lost their sheath though some sheathed larvae were obtained from some of the earthworms. Both measured between 560 to 640 mm, long,

Twenty earthworms examined before exposure to infection fax were negetive for the presence of larvae similarly 30 specimens examined from Jajura, where pigs are kept, were also not harbouring any larvae.

Infected guineapigs sacrificed mant on 80,95 and
110 day after exposure did not harbour any parasite to the
renal region. Press preparation of liver, lungs, mesenteric
lymph gland and kidney failed to show any parasite
similar negative result was obtained in rabbit killed on
the 10th day. But in the lungs of one rabbit killed on
the 125th, day two elongated nodules nearly in long were
seen and after incision brownish cheesy material was found
but no trace of larvae or adults parasite was present.

DISCUSSION

The observations in this experiment help to explain some intriguing aspects of stephanuriasis in this State and at the same time add some new informations hitherto uninvestigated.

Eutypheus waltoni, which is a very common annelid of this State, has been experimentally infected with the infective larvae of S. dentatus and has been found to harbour them for a very long time. The larvae recovered from this annalid were in far greater number than those recovered by Tromba (1955) and Batte et al. (1960) from E. feetida. Moreover, this has taken the infection more uniformly. All the earthworms exposed were found to harbour the parasite. The other variety probably belonging to Pheretima sp. also took the infection, Though further studies by feeding these parasitised earthworms to pigs could not be taken up due to certain limitations in this study, the role of these annelids in the biology and epidemiology of S. dentatus can be explained on the experimental evidences of other workers and certain circumstantial evidences observed during this study.

Tromba (loc.cit.) and Batte et al. (loc.cit.)
have established potent infection in pigs by feeding
parasitised E, feetida and have indicated the possible role
of this annelid in the biology of S. dentatus.E. waltoni
in this study have been found to be much heavily infected
and it can be presumed that after experimental feeding

with parasitised <u>E. waltoni</u> and Pheretima sp. (?) the infection can be produced in pigs. Thus provisionally these two species may be taken as a transport vector for the spread of <u>S. dentatus</u> until experimental works conclusively proved it.

Some circumstantial evidence also lends support for this presumption. The larvae cultured at widely varying room temperature from 23°C to 35°C showed higher mortality. Moreover, the sensitivity of S. dentatus larvae to environmental factors like low temperature heat, sunlight and drying have been reported by Spindler (1934) and other workers. If we consider these findings regarding the larval biology of S. dentatus against the climate of Bihar it becomes apparent that the climate is not very congenial for such a wide prevalence of this parasite in this State unless some other biological factor is involved. Thus the role of these two species of annelids infected experimentally for the first time with S. dentatus larvae becomes evident. They may be picking up the larvae and helping their survival in field conditions.

In the guineapigs and one rabbit, no trace of infection was found. But in the other rabbit the brownish cheesy material contained in the nodule of lungs was similar to that often found in the Stephanurus cysts containing the degenerated worm.

SUMMARX

1. 150 Deshi pigs at Patna and 4 pigs at
Gauriakarma Farm were examined postmortem and helminth
parasites were collected from them. Faecal samples
removed from in rectum were examined for protozoa.
The percentage of infection with different helminth
and protozoan parasites is recorded as follows:-

O.noverca 69.48 %, F.buski 15.58%, A.sufrartysex
32.47%, G.hominis 3.90%, P.crawfordi 5.20%, C.cellulose
7.14%, C.tenuicollis 2.60%, Hydatid cysts 5.84%,
A.strongylina 56.49%, P.sexalatus 47.15%, S.paradoxa 30.52%,
A.lumbricoides var.suum 23.38%, M.apri 1.95%, S.dentatus
79.87%, O.dentatum 34.49%, O.quadrispinulatum 15.58%,
O.brevicaudum 31.17%, T.trichiura 4.55%, Coccidia 47.4%, &
B.coli 66.88%.

- 2. Incidence of multiple infection was found to be very high with all three classes of helminths (Cestoda, Trematoda & Nematoda) and Protozoa. 10.4% of pigs harboured 2 species, 16.9% 3 species, 13% 4 species, 21.3% 5 species, 18.8% 6 speies, 7.8% 7 species, 7.1% 8 species and 1.3% 9 species of helminths. 31.2% of pigs harboured both B.coli and coccidia.
- 3. All parasites encountered except <u>G.hominis</u>
 var. <u>suis</u> and <u>F.buski</u> are reported from pigs in Bihar
 for the first time.

- 4. The morphology of helminths and protozoa was studied and their descriptions and measurements are furnished. The morphology of human and swine Ascaris lumbricoides has been compared and difference in lip denticles is noted.
- 5. Pathology of F.buski, O.noverca, A.lumbricoides
 var, xxxxx suum., S.paradoxa, M.apri and S.dentatus in
 natural infections is described.

Heavy fasciolopsiasis caused blockage of small intestine. O.noverca was found in the pancreatic duet causing proliferation of epithelium and infiltrative changes in lamina propria. The pathology of this species in the pancreas of pig is described for the first time.

Ascaris lumbricoides var. suum were found embedded in the bile duct and in the portal area outside the duct. Multilobular cirrhosis with different degrees od degenerative changes in the lobules was noted.

The female simondsia was lodged in pea-sized hard submucosal cysts in the stomach wall. In heavy infections the changes were those of subacute to chronic gastritis.

M.apri was found in bronchi and bronchioles.

Distinctive lobular areas of emphysema and consolidation were present.

S. dentatus was usually present in fibrous cysts embedded in perirenal fat but the juvenile and adult forms were found in such situations like pelvis of kidney, lungs, liver, abdominal and thoracic cavities.

Histopathologic changes are described.

Faecal samples of 436 pigs from two physiographic and climatic zones of Bihar were examined,

If for the helminth and protozoan infections. The percentage
of incidence is recorded as follows:-

In 100 pigs examined at Patna.

Opisthorchis sp. 55%, Fasciolopsis sp.9%,

Echinostome 23%, Gastrodiscoides sp.2%, Pseudanoplocephala

sp.8%, Spirurid worms 55%, Ascaris sp. 42%, Oesophagostomum

sp.57%, Trichuris sp. 3%, Metastrongylus sp.2%, Coccidia

57% and B.coli 66.88%.

In 336 pigs at Gauriakarma Farm.

Opisthorehis sp. 19.64%, Fasciolopsis sp.5.06%,

Echinostome 8.63%, Gastrodicoides sp.0.89%, Pseudanoplocephala
sp.1.29%, Spirurid worms 46.32%, Ascaris sp.54.46%,

Oesophagostomum sp. 53%, Trichuris sp. 63.3%, Metastrongylus
sp. 23.21%, Coccidia 42% and B.coli 38.4%.

Marked difference in regional prevalance has been foun in respect of <u>Trichuris</u> sp. and <u>Metastrongylus</u> sp. Their incidence was much higher in Gauriakarma Farm situated on Chotanagpur plateau than the plains at Patna, where the incidence was very low.

7. 30 samples positive for coccidia were sporulated and 3 species, <u>Eimeria scabra</u>, <u>E. debliecki</u> and <u>E. perminuta</u> were identified. All sporulated at room temperature in 10-11 days.

Lumbricoides var. Suum were studied after experimental infection with embryonated eggs in rats,gx guinea-pigs, rabbits, sheep, goats and pigs. They were sacrificed on four different periods, i.e. 5th, 10th, 64th and 82nd days of infection. Larvae migrated in all the animals and were recovered from liver and lungs on the 5th day and from lungs on the 9th day undergoing a significant development in size. Further development in the intestine was observed only in pig and a rabbit. The rabbit harboured 6 female and 2 male immature worms on the 39th day.

Dysphoea was the main symptom shown by the animals.

Rats were found to be less susciptible.

The pathologic changes were mainly found in liver and lungs. In the latter they were more marked on the 10th day evidenced by congestion, haemorrhage and areas of consolidation.

Histopathology revealed the larvae in the section of lungs, embedded in alvioli, blood vessels and bronchioles. Haemorrhage in alvioli, infiltration, congestion of blood vessels, desquammation of bronchiolar epithelium were the changes observed.

Liver displayed focal necrosis and infiltration at different places. Haematological studies ryealed eosinophilia in lambs and kids and a slight drop in neutrophile count.

9. Biology of S.dentatus was studied. Eggs cultured at room temperature (23 to 35°C) hatched in about 36 hours and the larvae reached infective third stage by the 5th & 6th days. Larvae culture and roome temperature showed greater mortality at different stages of their development, than those cultured at a constant temperature of 27°C.

Experimental infection with 3rd stage infective larvae obtained from water charcoal culture and culture in sheep faeces, was given to 2 species of earthworms. Eutyphens waltoni and Pheretina sp. From the former larvae were recovered from 1 to 40 days after exposure to infection. 12 to 48 larvae were present in the gut. Pheretina sp. took lighter infection. Out of 35 exposed 26 were found to harbour the larvae. Maximum larvae were recovered from the annelid and thosemb obtained from culture were identical except that the former had lost their sheath.

Three guinea-pigs and 2 rabbits were exposed to infective larvae. No development of the parasite was observed when sacrificed between 80 to 125 days.

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