

CANINE PIROPLASMOSIS. III.

MORBID ANATOMY.

BY G. S. GRAHAM-SMITH, M.A., M.B.,

*John Lucas Walker Student.**(From the Pathological Laboratory, Cambridge.)*

CONTENTS.

	PAGES
First appearance of Parasites in the peripheral circulation.—Percentage of Infected Corpuscles.—Condition of Infected Corpuscles.—Free Parasites	251—253
Phagocytosis.—Nucleated Red Cells	253
Relation of Infection to rise of Temperature	254
Urine	254
Appearances at Autopsy	254—256
Histology of organs. Lungs, Heart, Liver, Spleen, Kidneys, Supra-renals, Pancreas, Brain, Cord, Intestine, Lymphatic Glands, Mesentery, Marrow	256—264
Summary	264—266
Charts	255

IN the preceding paper the morphology of the parasites found in the peripheral circulation and in the organs of eleven dogs experimentally infected with Canine Piroplasmosis has been described. In the following pages will be considered the morbid lesions found in these dogs, and the proportions of the variously infected red corpuscles to one another, both in the organs and in the blood.

Dogs Nos. I and IV were given the disease by means of infected ticks, the others by the subcutaneous inoculation of blood from other infected dogs. All these dogs suffered from the acute, or subacute,

form of the disease, the duration of the disease varying between 13 (Dogs V and VI, puppies) and 47 days (Dog VIII).

Parasites in the peripheral circulation. In the majority of cases blood films were made daily from the date of infection to the day of death. The films were stained by Leishman's method, and thoroughly examined for the presence of parasites and nucleated red cells, and at the same time records were made of the proportion of corpuscles infected with one or more parasites.

Parasites were never seen in the films until several days after infection. The earliest date on which they appeared was the 6th day (Dog XI), and the latest the 36th day (Dog VIII). In most of the other animals they were first seen between the 8th and 12th days after infection.

Percentage of infected cells. The proportion of infected to non-infected red cells was only worked out in a few instances.

In Dog I from their first appearance until the day before death, the percentage of infected to non-infected red blood corpuscles varied between .3 and .6%. On the day before death it rose to 1.4%. At the autopsy 1% of the blood corpuscles from the heart were found to be infected.

In Dog II only .05% of the red blood corpuscles were infected 5 days before death. Two days later .3% were infected. On the day preceding death there were .8% of infected corpuscles and on the day of death 2.8%.

TABLE I. *Showing the percentage of infected corpuscles and the duration of the disease.*

	Percentage of infected corpuscles		Duration of the disease
	Day before death	Autopsy	
Dog VI	6.0 %	4.0 %	13 days
VII	4.0	.5	32
I	1.4	1.0	25
X	1.4	2.0	23
II	.8	2.8	23
XI	.5	1.2	17
III	.4	.8	22
IX	.3	.7	24
VIII	.2	.4	47
IV	.1	.4	23
V	?	.05	13

Canine Piroplasmosis

TABLE II. *Showing the numbers of parasites found in infected corpuscles in the peripheral circulation and heart's blood in eleven dogs.*

Number of parasites within infected corpuscles	Two days and more before death			The day before death			Heart's blood at the autopsy			Total																																																																																								
	No. of infected corpuscles counted	Percentage of various forms	No. of infected corpuscles counted	Percentage of various forms	No. of infected corpuscles counted	Percentage of various forms	No. of infected corpuscles counted	Percentage of various forms	No. of infected corpuscles counted	Percentage of various forms	No. of infected corpuscles counted	Percentage of various forms																																																																																						
I parasite	8,592	76.97 %	3,144	71.68 %	3,581	50.98 %	15,317	67.763 %	99.662 %	28.655	708	2.586																																																																																						
II parasites	2,314	20.73	1,122	25.58	3,086	43.11	6,472	28.655					III "	57	.51	20	.46	83	1.17	160	2.586	IV "	191	1.71	91	2.07	291	4.12	573	2.586	V "	3	.03	2	.04	4	.05	9	.089	VI "	4	.03	5	.11	16	.22	25	.117	VIII "	2	.02	2	.04	24	.34	28	.123	IX "	—	—	—	—	1	.01	1	.004	X "	—	—	—	—	1	.01	1	.004	XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98
III "	57	.51	20	.46	83	1.17	160	2.586	IV "	191	1.71	91	2.07	291	4.12	573	2.586	V "	3	.03	2	.04	4	.05	9	.089	VI "	4	.03	5	.11	16	.22	25	.117	VIII "	2	.02	2	.04	24	.34	28	.123	IX "	—	—	—	—	1	.01	1	.004	X "	—	—	—	—	1	.01	1	.004	XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961									
IV "	191	1.71	91	2.07	291	4.12	573	2.586	V "	3	.03	2	.04	4	.05	9	.089	VI "	4	.03	5	.11	16	.22	25	.117	VIII "	2	.02	2	.04	24	.34	28	.123	IX "	—	—	—	—	1	.01	1	.004	X "	—	—	—	—	1	.01	1	.004	XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																		
V "	3	.03	2	.04	4	.05	9	.089	VI "	4	.03	5	.11	16	.22	25	.117	VIII "	2	.02	2	.04	24	.34	28	.123	IX "	—	—	—	—	1	.01	1	.004	X "	—	—	—	—	1	.01	1	.004	XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																											
VI "	4	.03	5	.11	16	.22	25	.117	VIII "	2	.02	2	.04	24	.34	28	.123	IX "	—	—	—	—	1	.01	1	.004	X "	—	—	—	—	1	.01	1	.004	XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																																				
VIII "	2	.02	2	.04	24	.34	28	.123	IX "	—	—	—	—	1	.01	1	.004	X "	—	—	—	—	1	.01	1	.004	XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																																													
IX "	—	—	—	—	1	.01	1	.004	X "	—	—	—	—	1	.01	1	.004	XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																																																						
X "	—	—	—	—	1	.01	1	.004	XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																																																															
XII "	—	—	—	—	2	.02	2	.008	XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																																																																								
XVI "	—	—	—	—	1	.01	1	.004		11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																																																																																	
	11,163	100.00	4,386	99.98	7,040	100.04	22,589	99.961																																																																																										

From Table I (p. 251), in which the order has been arranged according to the degree of infection on the last day of life, it can be seen how greatly the degree of infection varies in acute cases.

Condition of infected cells. During the earlier stages of the disease the very great majority (70—90%) of the infected corpuscles observed contained single round parasites (Plate IX, Fig. 1). Occasionally two rounded or pear-shaped forms were met with, but cells containing more than two parasites were very scarce. At a later stage of the disease corpuscles containing more than one parasite became relatively more numerous, and on the day of death only half the infected corpuscles contained a single parasite.

In Table II is given a summary of the observations made on films from all eleven dogs, recording the number of parasites present in the infected corpuscles two days before death and earlier, the day before death, and at the autopsy a few hours after death.

It is interesting to observe that of the 7,272 corpuscles containing more than one parasite (young forms) 97·66% contain an even number of parasites and only 2·33% an odd number.

Free parasites were seldom encountered in the earlier stages but subsequently became more numerous. Two and more days before death one free parasite to every 38 infected corpuscles was found. The day before death the proportion was one free parasite to 23 infected corpuscles, and on the day of death one free parasite to 18 infected corpuscles.

Phagocytosis. Instances of leucocytes containing infected, or non-infected, red corpuscles, were only observed frequently in three dogs. In Dog I numerous instances of phagocytosis were seen in films taken 7, 2 and 1 days before death. They were not observed between the 6th and 3rd day before death. In Dog II the phenomenon was noticed two days before death, but not subsequently, and in Dog XI seven days before death, but not later. In films from the other dogs examples were only rarely met with. In smears taken from the various organs examples of phagocytosis were uncommon.

Nucleated red cells. Nucleated red cells were common in films from Dogs I, II, IX taken the day before death, and in films from Dogs VIII, XI, and IV, taken 6th, 3rd, and 2nd days before death respectively, and during the intervening days.

Relation of degree of infection to the temperature. Parasites were occasionally met with in very small numbers just before the rise of temperature, but in the majority of instances they were first observed on the date on which a definite rise of temperature took place.

In the case of Dog XI (Chart II) the temperature rose on the 6th day from 101·2° F. to 103° F. and on the 7th day had reached 105·3° F. From the 7th to the 13th day it fell gradually to 100° F., and then again rose to 103·3° F. on the 16th day. On the 17th day it rapidly went down to 95° F., and the animal died. Parasites were first observed in very small numbers on the 6th day, and were numerous from the 7th to the 10th days. On the 12th, 13th, and 14th days, when the temperature was low, parasites were scarce, but gradually again increased in numbers as the temperature again rose.

In the case of Dog IX (Chart I) although the parasites first made their appearance when the temperature rose on the 12th day their numbers remained very small during the first rise and during the subsequent fall in the temperature, and only became numerous during the final period of high temperature.

Urine. Specimens of urine from 8 dogs were obtained from the bladder within a few hours of death. Except in Dog VIII the urine was thick, dark-coloured, resembling tincture of iodine, and gave a large, darkly coloured deposit on standing. It was acid in reaction. Six of the samples contained albumin in considerable quantities, and six contained bile pigment. Five showed casts and three blood corpuscles on microscopical examination of the deposit. Blood pigment was present in all examples of urine except that from Dog VIII, which was normal in every respect. The urine of two out of the three male dogs contained spermatozoa in large numbers.

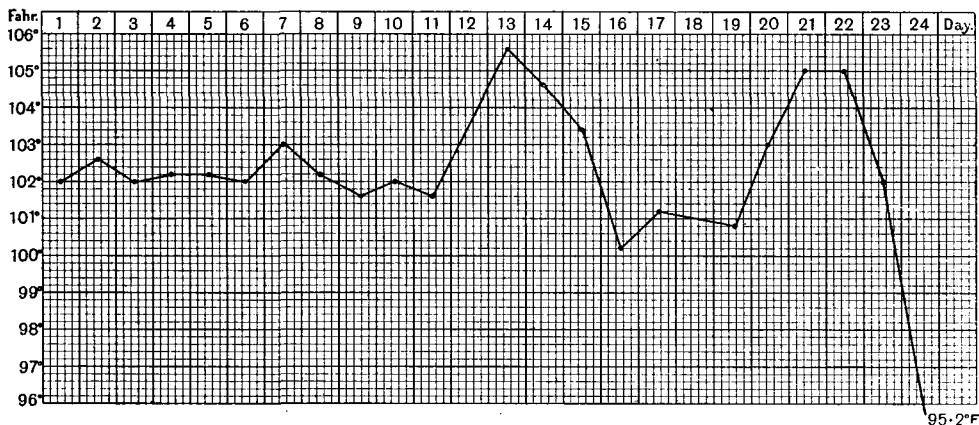
Appearances at the Autopsy.

Except that the mucous membranes were very pale and the subcutaneous tissues and fat more yellow than normal no constant gross lesions were observed at the autopsies. The stomach and intestines were usually empty, and the rectum loaded with bright yellow faeces. The urine in most cases was thick, and of a dark yellow colour, resembling tincture of iodine.

As shown in the table on pages 236–7 (Vol. IV, this *Journal*) other observers have laid stress on the enlargement of the spleen and con-

CHART I.

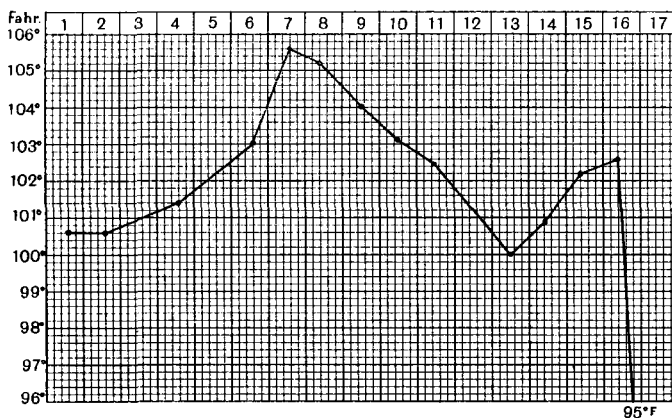
Dog IX. Infected by the subcutaneous injection of defibrinated blood from Dog VIII.



12th day, 4 parasites found. 13th day, 8 parasites found. 14th day, 34 parasites found. 15th day, 6 parasites found. 16th day, 11 parasites found. 17th day, 4 parasites found. 18th and 19th days, few parasites found. 20th day, parasites numerous. 21st, 22nd and 23rd days, parasites very numerous. 24th day, parasites very numerous (nucleated reds and phagocytes common).

CHART II.

Dog XI. Infected by the injection of 10 c.c. of defibrinated blood from Dog X.



6th day, 2 parasites found. 7th, 8th and 9th days, parasites numerous. 10th day, parasites numerous (many phagocytes). 11th day, parasites less numerous. 12th and 13th days, parasites few. 14th day, parasites few (nucleated reds common). 15th day, parasites more numerous (nucleated reds common). 16th and 17th days, parasites numerous (nucleated reds common).

gestion of the liver and spleen, with occasional enlargement of the former. Inflammation of the stomach and intestines has been especially frequently observed by Hutcheon.

In this series no macroscopic lesions were noted in Dogs IV, V, IX, X, and XI.

In Dog I the lungs were slightly oedematous. A few petechiae were observed in the stomach and omentum of Dog II. In Dog VI the lungs were oedematous, the spleen large and soft and the kidneys congested and very dark. In Dog VII the kidneys and suprarenals were congested and the spleen larger than normal. It contained three lymphomatous tumours. In the case of Dog VIII the spleen was large, soft and dark.

In some cases the blood was normal in appearance, but in Dog VII it was dark and of the consistency of treacle. In Dog III on the other hand the blood was represented by a yellowish fluid containing brown amorphous particles. This fluid became firmly clotted two hours after death.

The Histology of the Organs.

The organs were examined histologically by the following methods.

Small pieces were hardened either in Müller's reagent or in Bles' mercury solution, and cut in paraffin. Sections were stained by haematoxylin and counterstained by von Geison's method, and others were stained by Leishman's stain. In the latter case the sections, fixed on coverslips, were placed in distilled water containing a small quantity of Leishman's stain, and left for 12 to 24 hours. They were then placed in distilled water containing a drop or two of acetic acid for a few seconds, until the colour was pink, washed in distilled water, blotted dry, treated with xylol, and mounted in Canada balsam. By this means the parasites were brought out exceedingly well. In many cases other methods of staining were also adopted.

Smears on cover-glasses from the various organs were also prepared, stained by Leishman's stain in the same way as blood films and examined. From sections it was seen that in all cases the smaller capillaries contained more numerous infected corpuscles than the larger vessels. In the latter the infected corpuscles were generally to be found near the wall of the vessel. Consequently smears from the organs do not necessarily indicate the degree of infection, since the blood may be derived from any of the vessels. Care was taken to

obtain smears from places in which the larger vessels were not visible. Indications, however, may be obtained from the study of smears as to the degree of multiplication of the parasites within the blood corpuscles of the organ.

Lungs. The capillaries in the walls of the alveoli are as a rule dilated. Some of the alveoli are normal but in the majority there is proliferation of the lining cells, some of which are seen lying free in the air-cells. In other alveoli the process is more advanced, and numerous proliferated cells, leucocytes, and in some cases red-blood corpuscles are seen within them. The alveoli in which the process is more marked occur in groups of considerable size, which do not appear to have any relation to the bronchi or blood vessels.

Some of the bronchioles are normal, but many show proliferation of the epithelium, and the lumen frequently contains desquamated epithelium, leucocytes, and mucus.

There is no evidence of any increase in the connective tissue.

Blood vessels :—(1) The larger blood vessels appear to be normal but leucocytes are very common in them. Counts from the larger vessels showed between 12% (Dog X) and 1% (Dog VII) of infected corpuscles. (2) Smaller vessels show a larger number of infected corpuscles, which, as in the case of the larger vessels, generally lie close to the walls. (3) The capillaries in the alveolar walls are much dilated. Counts made from the capillaries in various sections showed between 52% (Dog X) and 4% (Dog VIII) of infected corpuscles.

The lungs of Dogs I, II, III, IX, and X showed the changes just described. In Dogs IV, V, VI and VII the changes were very marked. Enormous numbers of leucocytes were seen in the larger vessels, and there was much proliferation of the cells of the alveolar walls.

Smears show that 99·1% of all infected corpuscles contain between one and four parasites, and only ·89% contain more than four parasites. In the smears from Dog VIII one sausage-shaped organism (pp. 244, 245) was found, and in the same smears numerous forms with amoeboid processes were seen. Free parasites are very common, so that many can sometimes be counted in one field. The mean of all counts from lung smears shows that there are 1·5 free parasites to each infected red corpuscle.

TABLE III. *Summary of observations on all lung smears in regard to the numbers of parasites within infected corpuscles.*

No. of parasites within corpuscles	Infected corpuscles counted	Percentage of each variety	
I parasite	1,134	38.97 %	} 99.10 %
II parasites	1,524	52.37	
III "	31	1.06	
IV "	195	6.70	
V "	2	.07	} .89 %
VI "	9	.31	
VII "	1	.03	
VIII "	9	.31	
X "	3	.10	
XIV "	2	.07	
	2,910	99.99	

Heart. The *muscle* is normal and its striation well marked. No pigmentary or fatty changes were observed. The *capillaries* lying between the muscular bundles are much dilated, and in some places slight haemorrhages have occurred. Infected corpuscles in the capillaries are very numerous. In Dog III 72 % of the red corpuscles in some of these vessels were infected. In Dog VI there was extreme dilatation of these vessels, but in Dogs VIII, IX, X and XI it was comparatively slight.

No changes were noted in the *skeletal muscles*.

Liver. The changes in this organ were more marked than in any other. The following are the lesions which occur in the majority of cases.

The central vein of the lobule and the capillaries between the liver cells are extremely dilated. The protoplasm of the liver cells stains badly, but the nuclei take the stain fairly well. The cells are distorted between the dilated blood vessels, and are in many cases almost destroyed, especially near the centre of the lobule. The vessels in the interlobular spaces seem dilated, but the bile ducts are normal. There is no increase of fibrous tissue, and the capsule is normal.

The capillaries contain large numbers of red blood corpuscles and the proportion of leucocytes is high. The latter are also very numerous in the larger vessels. In these vessels about 10 % of the red corpuscles are infected, and are usually to be found in small groups near the walls. The proportion of leucocytes to red corpuscles in them is about 1 to 10.

In the capillaries 23% to 53% (Dog VI) of the red corpuscles are infected, and in some instances the proportion of leucocytes to red blood corpuscles is as high as 1 to 3.

In Dogs VIII and IX the dilatation of the capillaries was not so marked as in the others, and although very numerous leucocytes were present in the vessels the number of infected red corpuscles was not very great. The liver was very fatty in Dog VIII. In Dog VII the fibrous tissue in the interlobular septa was much increased.

Smears show that 98.98% of all infected corpuscles contain one to four parasites and 1.01% contain more than four parasites. Free parasites are found in the proportion of one to 2.5 infected cells.

TABLE IV. *Summary of observations on all liver smears in regard to the numbers of parasites within infected corpuscles.*

No. of parasites within corpuscles	No. of infected corpuscles counted	Percentage of various forms	
I parasite	2,183	40.84 %	} 98.98 %
II parasites	2,677	50.08	
III "	67	1.25	
IV "	364	6.81	
V "	10	.19	
VI "	12	.22	} 1.01 %
VII "	3	.05	
VIII "	25	.47	
X "	2	.04	
XII "	1	.02	
XVI "	1	.02	
	5,345	99.99	

Spleen. The capsule and malpighian bodies are normal. The pulp contains in most cases a large quantity of blood, and the vessels in the trabeculae are dilated and contain numerous leucocytes.

The proportion of infected corpuscles in the pulp is small, varying between 3.7% and 12%, but in the smaller trabecular veins it is high, in one case up to 48% (Dog I).

Smears show that 98.26% of all infected corpuscles contain one to four parasites, and 1.73% more than four. Free parasites occur in the proportion of 1 to 9.5 infected corpuscles.

TABLE V. *Summary of observations on all spleen smears in regard to the number of parasites within infected corpuscles.*

No. of parasites within corpuscles	Infected corpuscles counted	Percentage of each variety	
I parasite	2,474	46.27 %	} 98.26 %
II parasites	2,249	42.06	
III „	61	1.14	
IV „	470	8.79	
V „	14	.26	} 1.73 %
VI „	26	.48	
VII „	1	.02	
VIII „	45	.84	
X „	5	.09	
XIV „	1	.02	
XVI „	1	.02	
	5,347	99.99	

Kidneys. No changes were constantly observed in the kidneys except the dilatation of the blood vessels. The capillaries in the glomeruli are much distended, and so are the vasae rectae, and the vessels lying between the convoluted tubules. In most cases all the capillaries are crowded with infected corpuscles. For example in the section of a glomerulus, not differing from others (Dog I) 203 parasites were counted. In other cases about 46 % of all the red corpuscles seen in the vessels of the glomeruli were infected.

In the other capillaries of the organ large numbers of infected corpuscles were also counted, in some cases up to 95 % in the very small vessels. In Dog III about 50 % of all the corpuscles in these vessels were infected. The degree of infection, however, was not so great in Dogs IV and V, and in Dogs VIII and IX the dilatation was much less marked than in others, although the proportion of infected corpuscles was very high.

Smears show that although the proportion of infected corpuscles in the vessels of the kidney is very high the multiplication of the parasites within the corpuscles is not very great, for 99.01 % of all infected corpuscles contain one to four parasites, and only .93 % more than four parasites. Free parasites occur in the proportion of 1 free parasite to 2.2 infected corpuscles.

Two of the sausage-shaped organisms described in the previous paper (p. 244) were met with in the kidney smears of Dog IX.

TABLE VI. *Summary of observations on all kidney smears in regard to the number of parasites within infected corpuscles.*

No. of parasites within corpuscles	Infected corpuscles counted	Percentage of each variety	
I parasite	2,802	48.37 %	} 99.01 %
II parasites	2,521	43.52	
III "	110	1.89	
IV "	303	5.23	
V "	10	.15	} .93 %
VI "	23	.39	
VII "	2	.03	
VIII "	21	.36	
	5,792	99.94	

Suprarenal Capsules. The vessels of the suprarenal capsules both in the cortex and the medulla are dilated in the majority of cases. Otherwise the gland is normal. In Dog III about 70 % of the corpuscles in some of the smaller capillaries were infected.

Smears show that a comparatively large proportion of the infected corpuscles (1.91 %) contain more than four parasites. Free parasites occur in the proportion of one free parasite to 4.8 infected corpuscles.

TABLE VII. *Summary of observations on all suprarenal smears in regard to the number of parasites within infected corpuscles.*

No. of parasites within corpuscles	Infected corpuscles counted	Percentage of each variety	
I parasite	480	34.33 %	} 98.05 %
II parasites	727	52.00	
III "	24	1.71	
IV "	140	10.01	
V "	3	.21	} 1.91 %
VI "	11	.78	
VIII "	12	.85	
X "	1	.07	
	1,398	99.96	

Pancreas. In all cases the cells of the pancreas stain badly. The protoplasm is granular, especially at the inner zone, and the nuclei stain faintly, and in some cases can scarcely be made out. In all cases the capillaries and smaller vessels are greatly dilated and contain numerous infected corpuscles. The proportion of free parasites to infected corpuscles was one to nine.

TABLE VIII. *Summary of observations on all pancreas smears in regard to the number of parasites within infected corpuscles.*

No. of parasites within corpuscles	Infected corpuscles counted	Percentage of each variety	
I parasite	952	50.93 %	} 99.72 %
II parasites	825	44.14	
III „	10	.53	
IV „	77	4.12	
VI „	3	.16	} .26 %
VIII „	2	.10	
	1,869	99.98	

Brain. Sections of various parts of the brain showed no changes except slight dilatation of the capillaries in the substance and meninges. In some cases there was an excess of cerebro-spinal fluid.

The degree of infection in the capillaries is in most cases high. In Dog III for example 42 red corpuscles were counted in one capillary of which 37 or 88 % were infected. Free parasites are very numerous in smears from the brain, the proportion being 1 free parasite to 2 infected corpuscles. The proportion of infected corpuscles containing more than four parasites is higher in the brain than in any other organ, namely, 4.91 % of all infected corpuscles.

TABLE IX. *Summary of observations on all brain smears in regard to the number of parasites found within infected corpuscles.*

No. of parasites within corpuscles	Infected corpuscles counted	Percentage of each variety	
I parasite	304	38.33 %	} 95.07 %
II parasites	317	39.97	
III „	16	2.02	
IV „	117	14.75	
V „	2	.25	} 4.91 %
VI „	11	1.38	
VIII „	20	2.52	
XII „	2	.25	
XIV „	1	.13	
XV „	1	.13	
XVI „	2	.25	
	793	99.98	

Spinal Cord. Nothing abnormal was noticed except slight dilatation of the vessels of the substance and meninges.

Small Intestine. The vessels of the villi are much dilated and

crowded with infected corpuscles. A considerable number of leucocytes are found in the vessels and connective tissue spaces.

Mesentery and Omentum. Pieces of the mesentery and omentum were stretched out on cork, fixed by formalin vapour, and stained by Leishman's method. In nearly all the specimens the smaller vessels were seen to be crowded with infected corpuscles and leucocytes (Plate X, Fig. 2).

Lymphatic glands. Except for the dilatation of the smaller vessels the lymphatic glands are normal. Free parasites occur in the smears in the proportion of one free parasite to 2.2 infected corpuscles. The number of infected corpuscles containing more than four parasites is higher than any other organ except the brain (4.74%).

TABLE X. *Summary of observations on all lymphatic gland smears in regard to the number of parasites found within infected corpuscles.*

No. of parasites within corpuscles	Infected corpuscles counted	Percentage of each variety	
I parasite	253	40.03 %	} 95.25 %
II parasites	291	46.04	
III "	2	.32	
IV "	56	8.86	
V "	1	.16	} 4.74 %
VI "	6	.94	
VII "	1	.16	
VIII "	17	2.69	
X "	2	.31	
XII "	1	.16	
XVI "	2	.32	
	632	99.99	

Marrow. Smears were made from marrow taken from the shaft of the femur.

As will be seen from the following table the proportion of corpuscles containing two and more parasites was very high. Corpuscles containing 4, 6, and 8 parasites amounted to 15.38% of all of those infected, and corpuscles containing more than 4 parasites to 3.94%. The examination of these films in which there were large numbers of nucleated red cells only showed one infected with parasites (Plate IX, Fig. 45). The percentage of infected corpuscles was very high, but varied greatly in the different dogs. Free parasites occurred in the proportion of one free parasite to 8 infected red corpuscles.

Summary.

In the present series of acute cases no constant macroscopical lesions were found at the autopsies. Histologically it was found that the blood vessels of the organs were dilated, and contained very large numbers of leucocytes. In the majority of cases parasites were seen in great numbers in the small capillaries, a high percentage of the blood corpuscles being infected. In the larger vessels a much smaller proportion of the corpuscles contained parasites, and these were usually found near the periphery of the vessel.

TABLE XI. Summary of observations on all marrow smears in regard to the number of parasites within infected corpuscles, and TABLE XII, showing percentage of infected red corpuscles.

TABLE XI.			TABLE XII.	
No. of parasites within corpuscles	Infected corpuscles counted	Percentage of each variety	Dog	Percentage of infected corpuscles
I parasite	2,562	29.59 %	VI	53.5 %
II parasites	4,508	52.06	XI	42.5
III "	168	1.94	X	37.0
IV "	1,083	12.39	II	35.0
V "	35	.40	IX	22.0
VI "	103	1.19	III	21.0
VII "	11	.18	VII	11.3
VIII "	156	1.80	I	9.0
IX "	3	.03	V	4.5
X "	10	.11	IV	2.0
XII "	2	.02	VIII	2.0
XIII "	1	.01	Mean	22 %
XIV "	1	.01		
XVI "	13	.15		
XVII "	2	.02		
XVIII "	1	.01		
XXI "	1	.01		
	8,660	99.92		

Corpuscles containing more than four parasites were found in the greatest numbers in the brain, lymphatic glands, and marrow. It is therefore probable that multiplication within the corpuscles is more rapid in the capillaries of these organs than in other situations.

TABLE XIII. *Showing the relative proportion of infected corpuscles containing more than four parasites.*

Brain	4·91 %	Kidney	·93 %
Lymphatic glands	4·74	Lung	·89
Marrow	3·94	Heart blood... ..	·66
Suprarenal capsules	1·91	Pancreas	·26
Spleen	1·73	Blood (day before death)	·19
Liver	1·01	„ (2 and more days before death)	·08

The liver showed changes due principally to the pressure of the dilated capillaries, and the lungs were in most cases in a condition resembling bronchopneumonia.

Phagocytosis of the infected cells was common in some cases a few days before death, and nucleated red cells were frequently encountered in the peripheral circulation towards the end of the disease.

TABLE XIV. *Showing the relative frequency of the occurrence of infected red corpuscles containing various numbers of parasites compiled from all the observations made on organ smears and blood films.*

No. of parasites in infected corpuscles	No. of infected corpuscles counted	Percentage of each variety		
I parasite	28,414	51·196 %	} 98·672 %	
II parasites	22,286	40·155		
III „	666	1·200		
IV „	3,397	6·121		
V „	89	·160		
VI „	231	·416		
VII „	19	·034		
VIII „	334	·602		
IX „	4	·007		
X „	24	·043		
XII „	8	·014	} 1·326 %	
XIII „	1	·001		
XIV „	4	·007		
XV „	1	·001		
XVI „	20	·036		
XVII „	2	·003		
XVIII „	1	·001		
XXI „	1	·001		
	55,502	99·998		

The preceding table, compiled from all the observations on films from the peripheral blood and smears from organs, shows the relative frequency of blood corpuscles containing various numbers of parasites.

It shows that over 91% of all infected corpuscles contain either one or two parasites only, and that 98.6% contain one to four parasites.

Even numbers of parasites are present in 97.11% of all infected corpuscles containing more than one parasite and odd numbers in only 2.88%.

Free parasites are found most frequently in lung smears, next most frequently in brain, lymphatic gland and liver smears, and less frequently in smears from other organs. At all times they are less common in the peripheral circulation.

The following table gives the proportion of free parasites to infected corpuscles in smears from the different organs and blood films.

TABLE XV. *Showing the proportion of free parasites to infected corpuscles.*

Organs					
Lungs	...	...	...	...	1.5 free parasites to 1 infected cell.
Brain	...	...	...	...	1 " " 2 " "
Lymphatic gland	...	...	...	...	1 " " 2.2 " "
Kidney	...	...	...	...	1 " " 2.2 " "
Liver	...	...	...	...	1 " " 2.5 " "
Suprarenal gland	...	...	...	...	1 " " 4.8 " "
Marrow	...	...	...	...	1 " " 8 " "
Pancreas	...	...	...	...	1 " " 9 " "
Spleen	...	...	...	...	1 " " 9.5 " "
Blood (autopsy)	...	...	...	...	1 " " 18 " "
" (day before death)	...	...	...	...	1 " " 23 " "
" (2 and more days before death)	...	...	...	...	1 " " 38 " "

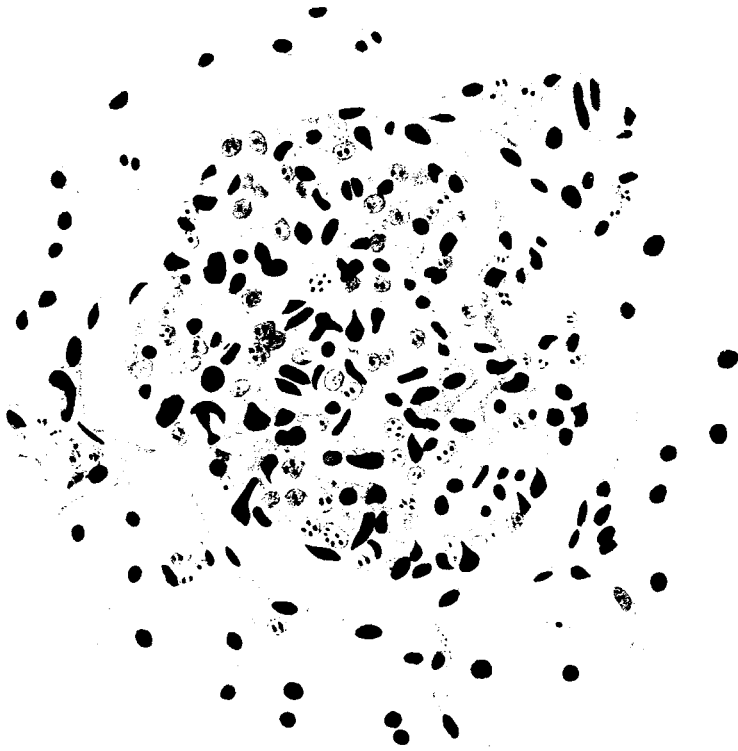
The urine taken from the bladder at the autopsy is generally very darkly coloured, and contains albumen, bile salts, and blood pigment, and in the case of male dogs spermatozoa.

EXPLANATION OF PLATES X AND XI.

All specimens stained by Leishman's stain by the method described on p. 256.

PLATE X.

- Fig. 1. Glomerulus from the kidney of Dog I, showing very numerous infected red corpuscles in the capillaries.
- Fig. 2. Portion of a small vessel from the omentum of Dog V, showing large numbers of infected red corpuscles and numerous leucocytes.
- Fig. 3. Part of the liver of Dog I, showing greatly dilated capillaries containing many infected red corpuscles and numerous leucocytes.
- Fig. 4. Portions of the walls of lung alveoli showing numerous infected corpuscles in the capillaries.



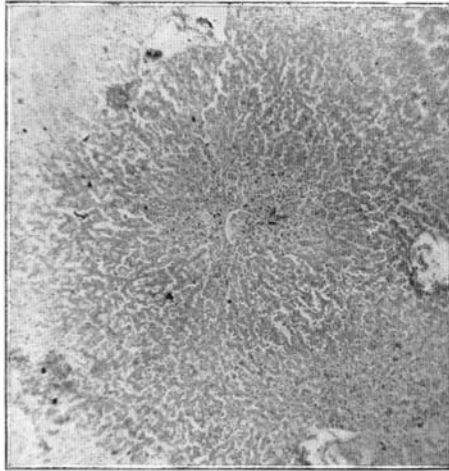


Fig. 1.

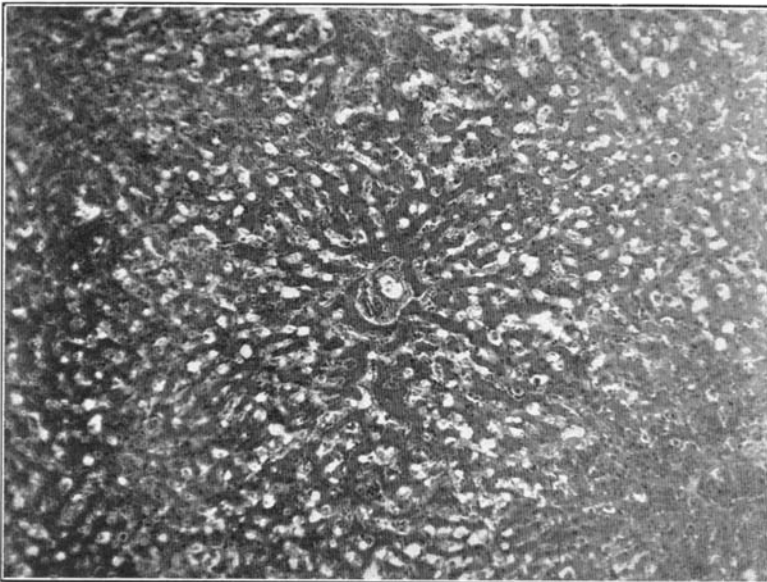


Fig. 2.

PLATE XI.

- (1) Micro-photograph of a lobule of the liver showing at the periphery dilated capillaries (white) between the liver cells (dark). The capillaries can be traced almost up to the central vein. In this region the liver cells are much atrophied and numerous leucocytes are present in the capillaries. (Magnification about 45.)
- (2) Micro-photograph of the periphery of a lobule showing the greatly dilated capillaries (white) containing numerous leucocytes (dark nuclei). Liver cells dark. (Magnification about 66.)