

EPERYTHROZOOM SUIS N. SP., THE ETIOLOGICAL
AGENT OF ICTERO-ANEMIA OR AN ANAPLAS-
MOSIS-LIKE DISEASE IN SWINE.

by

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INTRODUCTION

A disease entity characterized by generalized icterus and acute anemia has been recognized for a number of years in swine in the midwestern states. This sporadic condition was first reported by Kinsley (1932), and later that year by Doyle (1932). Since the initial description of the disease articles have been written by Kinsley and Ray (1934), Dicke (1934), Quin (1938), Spencer (1940), Robb (1943), and Campbell (1945). These investigators have been in complete agreement in regard to symptoms, gross pathology, clinical history, and various other aspects concerning the disease. It has appeared that this is a distinct disease entity of swine, and because of the similarity to bovine anaplasmosis it has been called "anaplasmosis-like disease" or "ictero-anemia". The etiology of the disease remained unknown.

The investigations which are reported in this thesis were begun following the observation by the author of an unreported blood parasite in swine. The organism was found associated with field cases of "ictero-anemia" or "anaplasmosis-like disease". These studies were begun with the primary purpose of establishing whether or not this parasite is in any way responsible for the disease with which it was found associated.

Clinical and laboratory data were gathered from a number of field outbreaks of the "anaplasmosis-like" disease. The disease was reproduced in experimental swine, and the resulting symptoms, disease process, and pathology were compared to those of field cases in order to establish proof of the etiology of the disease.

Studies were undertaken to differentiate the organism from Eperythrozoon species of other animals, and from another Eperythrozoon found in these investigations in swine. Experimental studies of the chemotherapy of the disease were also conducted. Dr. David Weinman of the Yale University School of Medicine; Dr. Rue Jensen, Colorado A. and M. College; and Dr. W. O. Neitz, Onderstepoort Laboratory, Union of South Africa have concurred in the identity of the two species observed as members of the genus Eperythrozoon. The parasite which was observed in field cases of "ictero-anemia" was given the name Eperythrozoon suis, and Eperythrozoon parvum is the name given to the organism found during these experimental studies. At the time of this writing, E. suis has been found associated with a total of eight herd outbreaks of "ictero-anemia". Six of these occurred in Iowa and two in Kansas.

Various investigators in the past have reported the presence of what appeared to be hemotropic micro-organisms associated with the "anaplasmosis-like" disease of swine. Kinsley (1932) observed a spherical body in the erythrocytes that resembled Anaplasma. Doyle (1932) described the structure he observed as follows:

Blood smears stained with Giemsa stain showed the presence of bodies, evidently organismal in nature, within the red cells. These bodies showed considerable variation in morphology. Some were coccoid, some bacilliform, while still others were ring formed. The ring formed bodies often showed small chromatin knots or masses at certain points on their circumference. Some of the erythrocytes were almost filled with these bodies, and many of the bodies were free from the red cells.

Dicke (1934) gives a similar account of an organism he observed in cases of "ictero-anemia". The descriptions given by the two

latter men are similar to the description of E. suis, with certain variations which will be noted later.

Robb (1943) observed similar structures associated with "ictero-anemia" and also in normal swine. He concluded that the structures were actually artifacts having no connection with this disease. Doyle (1945) stated that the red cell inclusions in typical "ictero-anemia" are more suggestive of Bartonella than they are of Anaplasma. Quin (1938) believed the disease to be transmitted by vectors, and the causal agent to be a Piroplasma or Anaplasma. Kinsley and Ray (1934), Robb (1943), and Dykstra and co-workers (1948) reported failure in attempts to transmit the disease to normal swine. In a recent survey Harshfield (1949) reported occurrences of this disease in ten states, four of which observed it in 1948. Breed (1950) describes an ictero-anemic condition in young pigs which he has attributed to improper nutrition. He states that the blood cells contain many bodies which may be mistaken for blood parasites.

Blood parasites of the genus Eperythrozoon (E. coccoides) were first observed by Schilling (1928) in splenectomized mice. Bruynoghe and Vassilaidis (1929) described E. dispar of the vole. Adler and Ellenbogen (1934) reported the presence of an Eperythrozoon in cattle in Palestine. They found the organism associated with Theileria annulata and Anaplasma. Neitz, Alexander, and Du Toit (1934) reported a new species, E. ovis, in African sheep. In classifying the genus, Eperythrozoon, these workers were of the opinion that the organism is closely related to Bartonella, Grahamella, and Anaplasma. Their selection of this classification

was based not only on morphology, but also on symptoms and course of the disease process. A common symptom resulting from these organisms is an anemia characterized by degenerative and regenerative changes in the blood. These changes occur sometime after the appearance of the parasite, in a manner similar to that observed in infections with Anaplasma. Eliot (1936) succeeded in transmitting E. coccoides with the louse, Polyplax serrata. Neitz (1937) described an acute, febrile anemia of sheep resulting from experimental infection with E. ovis. He found the post mortem lesions to be identical with those of acute anaplasmosis. Neitz (1940) reported observations on eperythrozoonosis of African cattle. The parasite appeared to be identical to E. wenyoni of Palestine cattle.

Lotze and Yiengst (1941) first reported the presence of E. wenyoni in cattle in the United States, and found it to be associated with bovine anaplasmosis. Jensen (1943) found the same organism in mixed infections with anaplasmosis, and in calves unassociated with anaplasmosis in Louisiana. Jensen (1943) also found E. ovis to be an apparently common blood parasite of native Louisiana sheep. His work corroborated that of Neitz (1937) in demonstrating that the parasite is capable of producing an acute, febrile anemia and icterus in susceptible, unoperated sheep. Dykstra et al. (1948) reported the presence of E. wenyoni associated with bovine anaplasmosis in Kansas.

Tyzzer and Weinman (1939) found E. dispar to be a common parasite of the vole, Microtus pennsylvanicus, in the eastern United States. Tyzzer (1942) reported a new species, E. varians,

in the field mouse, Peromyscus maniculatus. Clark (1942) observed an Eperythrozoon in a cat in South Africa. The organism was found associated with an acute and fatal anemia. No experimental work with this parasite was undertaken.

In the therapy of Eperythrozoon and Bartonella infections, investigators found various arsenicals and arsenic-antimony compounds to exert a parasitocidal action. Mayer, Borchardt, and Kikuth (1927) found the organic arsenicals neosalvarsan, atoxyl, and tryparsamide to have high therapeutic value against Bartonella muris. Amako (1930) reported that neosalvarsan and atoxyl have a distinct prophylactic and therapeutic effect on B. muris. Kikuth (1932) reported a new antimony-arsenic compound, Std. 386B, to have a therapeutic index of 1:3,500 against B. muris. Mayer and Malamos (1936) noted drug-fastness in B. muris from repeated injections of increasing doses of neosalvarsan and Std. 386B. Bruynoghe and Vassiliadis (1929) were prompted by the close relationship of Eperythrozoon and Bartonella to investigate therapy of the former disease with neosalvarsan. This compound was found to exert a specific action on E. coccoides. Sulfarsenal and tryparsamide were also found to be effective. Tyzzer (1941) found sulfarsphenamine to be effective against E. coccoides. Neitz (1937) obtained specific therapy of acute eperythrozoonosis of sheep with neosalvarsan and Std. 386B. Neosalvarsan was administered intravenously, and specific parasitocidal action was obtained in single doses varying from 10 to 45 mg/kg. The larger doses completely eliminated heavy blood infections within 15 minutes. Doses less than 10 mg/kg were ineffective.

MATERIAL AND METHODS

In the studies made on field outbreaks of "ictero-anemia" in swine in Iowa, the author received assistance from Dr. R. L. Williamson, Essex, Iowa. Clinical data and blood films from animals in the Iowa outbreaks were assembled by Dr. Williamson, and forwarded to the Veterinary Research Laboratory at Manhattan, Kansas. Pigs showing clinical symptoms and those normal animals in the herds that were re-examined were ear-tagged to provide proper means of identification. No attempts were made to conduct blood counts on the Iowa pigs other than one which was shipped to the laboratory; however Tallquist readings of the hemoglobin were made on animals showing clinical symptoms.

In the herds under investigation near Manhattan, Kansas, (herds C and D) blood films were obtained from all of the animals in both groups. Daily blood examinations were made on the animals showing clinical symptoms. In herd C hematological studies were made on alternate days on three pigs in order to study the blood changes in subclinical cases. Two of these pigs suffered a relatively heavy parasitic infection, and the third a very mild degree of infection. Blood examination of these three pigs was continued over a period of 12 days.

All blood films obtained in these studies were prepared for microscopic examination by staining with Giemsa stain. The blood picture as observed in stained smears from field cases was taken as a rough measurement of the animals response to erythrocytic destruction. Although polychromatophillic and varying numbers of

Howell-Jolly bodies are normally present in swine of the age groups studied, the abnormal increase in numbers of these immature cells can be observed rather easily in clinical and sub-clinical cases of the "anaplasmosis-like disease".

Blood samples for laboratory examination were obtained from the anterior vena cava. Blood smears were prepared immediately upon drawing the blood. Erythrocyte and leukocyte counts, hemoglobin determinations, and packed erythrocyte volumes were determined daily. The icteric index also was determined when icteric serum was evident.

In acutely affected animals pipettes for erythrocytic counts were prepared at the time of obtaining blood, to insure greater accuracy of results. In these animals a marked agglutination of erythrocytes occurred in citrated or oxalated blood, and prevented accurate enumeration in samples so treated. Erythrocyte and leukocyte counts were made using the improved Neubauer hemocytometer. Hemoglobin values were determined with a Klett-Summerson photoelectric colorimeter. Packed erythrocyte volume and blood sedimentation were determined by the use of Wintrobe hematocrit tubes. The icteric index was determined by visual comparison with known standards.

Intravenous injections were made into the anterior vena cava. Considerable care was taken, particularly with neocarsphenamine, to deposit all of the substance within the vein. No untoward effects were observed from repeated daily punctures of the vein or from injections made at this site. Those cases that came to post-mortem revealed only a slight amount of hemorrhagic infil-

tration into the tissues surrounding the vein. Individual sterile needles were used in obtaining blood samples to prevent accidental transmission of Eperythrozoon parasites. The neocarsphenamine and sodium cacodylate used in these studies were purchased at a local veterinary supply house.

Splenectomy operations were performed under intravenous anesthesia with sodium pentobarbital. The operations were conducted with ease, and no unusual surgical techniques were required.

All susceptible swine, the calf, sheep, and mice were held under conditions as nearly fly-free as possible to prevent accidental transmission of Eperythrozoon from known infected animals. Susceptible pigs were held in screened, fly-proof stalls at a distance of about 50 yards from infected pigs.

An arbitrary means of indicating the degree of parasitic infection was used in these studies, and is designated as follows: Rare - one Eperythrozoon structure in five to ten or more microscopic fields; Scarce - one structure in one to five microscopic fields; Occasional - approximately 10 to 20 per cent of the erythrocytes containing at least one or more eperythrozoa; Frequent - approximately 50 per cent of the erythrocytes containing one or more eperythrozoa; Numerous - approximately 80 to 90 per cent of erythrocytes containing one or more eperythrozoa; Very numercus - all erythrocytes infected and some completely covered with parasites; Extremely numerous - all erythrocytes infected and many completely covered with parasites.

OBSERVATIONS ON FIELD CASES OF "ICTERO-ANEMIA"

Herd A

This herd, located near Shenandoah, Iowa, consisted of 77 pigs, a number of sows, and a boar. On May 9, 1949, the pigs were vaccinated with hog cholera serum and virus. Approximately four weeks later two sows and two pigs sickened and died. Post-mortem examination of the dead pigs revealed a generalized icterus; thin, watery blood; a greatly enlarged, friable spleen; and an orange-yellow discoloration of the gastro-intestinal contents. No lesions suggestive of hog cholera were observed in these pigs, or in pigs that died later.

Between June 1 and August 1, a total of 39 pigs died with this condition. Clinical symptoms were identical to those of the "ictero-anemia" or "anaplasmosis-like" condition described in the literature. A sick pig from this herd was shipped to a diagnostic laboratory on July 13, 1949. The laboratory report stated that lesions typical of the "anaplasmosis-like" condition in swine were observed. No bacterial growth was found on culturing the tissues. Microscopic examination of blood smears disclosed the presence of many "anaplasmosis-like" bodies in the red cells.

On July 23, 1949, two sick pigs weighing approximately 80 pounds each were delivered to the Kansas State College Veterinary Research Laboratory. One pig died enroute, and a post-mortem examination revealed typical lesions of "ictero-anemia". Examination of stained blood films from the two pigs disclosed the pres-

ence of a micro-organism (Eperythrozoon suis) very similar in appearance to Eperythrozoon wenyonii and E. ovis. Table 1 indicates the degree of parasitic infection as pig 1 progressed toward recovery. Blood films were obtained from four additional pigs from this herd, two of which were visibly affected and two apparently normal. Subclinical anemia developed in both normal pigs, and acute, ictero-anemia was evidenced in the clinically affected animals. Eperythrozoon parasites were observed in all four animals. The detailed results of these blood examinations are given in Table 2.

To determine the presence or absence of hog cholera virus, and to attempt transmission of E. suis, four cubic centimeters of citrated blood from pig 1 was injected intravenously into two cholera-susceptible pigs. One pig was given 30 cc of anti-hog-cholera serum subcutaneously. Both pigs remained normal after a period of 45 days. Eperythrozoea appeared in both animals, the resulting parasitic infection being very mild with no clinical symptoms evident. The susceptibility of these pigs to Eperythrozoon was not proved prior to inoculation. It is, therefore, unknown whether the animals were in a state of premunition, or the infection observed was a recrudescence of a latent infection or an actual transmission. Blood films from both animals were negative prior to inoculation. E. suis was present in both after twenty-four hours. A third pig, not inoculated, showed eperythrozoea twenty-four hours after being confined in a pen with pig 1. A blood examination was not obtained prior to placing this animal in contact with the sick pig. It is assumed the animal was al-

ready harboring E. suis.

Herd B

This herd, located near Shenandoah, Iowa, consisted of 124 pigs in addition to the sows and boar. The pigs were vaccinated for cholera by the simultaneous method on May 7, 1949. On August 19, a post-mortem examination was made on a pig that had been sick about one week. Typical lesions of "ictero-anemia" were observed. Blood films were not obtained from this animal. Smears were, however, obtained from two additional pigs showing early clinical symptoms, and five apparently normal pigs selected at random. E. suis was found in two of the apparently normal pigs, and in both animals showing clinical symptoms. As indicated in Table 2, an increased temperature and a subclinical anemia were present in one of the apparently normal pigs which was harboring eperythrozoa.

Herd C

This group of swine consisted of 17 pigs weighing approximately 125 pounds, and 2 brood sows. The pigs had not been immunized to hog cholera. Examination of a sick pig (pig 12, Tables 1 and 2) from this herd was made after the animal had been noticeably ill for five days. Symptoms and data obtained on blood examination were typical of the "anaplasmosis-like disease", icteric discoloration of the mucous membranes was not evident, however. E. suis was observed in smears from this animal. Table 1 indicates the progress toward recovery. A mild relapse developed in this

pig as indicated in the data by a recrudescence of the parasitic infection, followed by an increased body temperature and marked lowering of the erythrocytic count and hemoglobin values.

Examination of the remaining 16 pigs in the herd disclosed E. suis to be present in the following degrees of infection: three pigs were negative for parasites; in six pigs the parasites were rare; in four the parasites were scarce; and in one pig each the organisms were occasional, frequent, and numerous. As previously stated, blood studies were made on the two latter animals. A third pig, in which the parasites were scarce, was used as a control. Data obtained from pig 10 in which the parasites were most numerous are included in Table 1. The blood count in this pig at 9,390,000 per cu mm dropped to 6,820,000, the hemoglobin dropping from 15.1 to 12.2 grams per 100 cc of blood. Blood values returned to nearly normal following the disappearance of the parasite. The erythrocyte count in the second pig at 8,410,000 per cu mm dropped to 6,130,000, the hemoglobin dropping from 14.9 to 12.2 grams per 100 cc of blood. Blood counts in the control pig at 8,490,000 dropped to a low of 8,060,000 per cu mm; hemoglobin values at 14.8 reached a low of 14.3 grams per 100 cc of blood. Increased regenerative blood changes were evident in the two former pigs, being most marked in pig 10 which showed the heaviest infection of eperythrozoa. The blood picture remained unchanged in the control. Temperatures of pig 10 ranged from an initial high of 105.0°F. down to 103.1°F. That of the second pig ranged from an initial temperature of 103.8° down to 102.6°F. Temperatures of the control pig, initially at 102.4°F.,

varied a maximum of only 0.4 of a degree during the entire course of examination. Temperatures of several other pigs selected each time at random remained between 102.0° and 103.5°F.

Herd D

This group consisted of six cholera susceptible hogs located near Riley, Kansas. Five of the animals were approximately ten months of age. A boar of unknown age was introduced into the herd on December 30, 1949. One of the original animals in the group became ill on February 7, 1950, and was brought to the Veterinary Hospital four days later. A diagnosis of acute, hemolytic anemia was made. Blood films examined by the author revealed the presence of E. suis. The laboratory data gathered in this case is given in Table 1. Blood films obtained from the five normal pigs revealed a mild parasitic infection in two. Hog lice were numerous on all six animals.

MICROSCOPIC BLOOD EXAMINATION OF NORMAL SWINE

A study was made of the blood of apparently normal swine to determine the number of animals that might be harboring Eperythrozoon in visible numbers. Robb (1943) found ring-shaped structures both in cases of "ictero-anemia" and in normal swine. His description of these structures suggested that he may have observed Eperythrozoon. Blood films were obtained at a local livestock sales pavilion from 25 apparently normal swine representing six separate herds. These pigs ranged in size from 20 to 180

Table 1. Blood values observed during clinical and subclinical "ictero-anemia" (acute eperythrozoosis).

Date	Temp.	R.B.C.	Hemo- globin	Degree of Eperythrozoon infection	Anemic changes in blood film
Fig 1					
7-23	106.0	2,110,000	3.9	Numerous	Frequent
25	103.8	3,620,000	7.2	Frequent	Marked
27	103.0	6,080,000	10.1	Scarce	Frequent
30	102.7	5,160,000	12.8	Scarce	Normal
8- 4	102.2	7,320,000	13.5	Negative	Normal
Fig 10					
8- 4	105.0	9,390,000	15.1	Numerous	Normal
6	103.5	9,070,000	13.8	Numerous	Normal
8	103.3	7,527,000	12.2	Frequent	Frequent
10	104.6	6,820,000	12.5	Scarce	Numerous
12	103.4	7,390,000	13.6	Negative	Numerous
15	103.1	8,980,000	14.6	Negative	Nearly normal
Fig 12					
8- 2	103.1	2,220,000	2.6	Rare	Numerous
3	102.5	3,120,000	4.5	Occasional	Numerous
4	103.0	3,730,000	7.7	Frequent	Numerous
5	105.7	2,310,000	4.7	Occasional	Numerous
6	102.7	3,700,000	7.2	Rare	Numerous
10	103.0	4,480,000	12.2	Negative	Frequent
15	102.4	7,980,000	13.1	Negative	Nearly normal
1950					
Fig 13					
2-11	103.6	3,210,000	7.7	Occasional	Frequent
14	102.2	2,580,000	6.9	Scarce	Numerous
16	101.9	2,840,000	7.0	Rare	Marked
18	101.4	4,990,000	11.4	Rare	Numerous
20	101.0	4,460,000	10.4	Rare	Frequent

1. Erythrocytes per cubic millimeter.
2. Expressed in grams per 100 cc of blood.

Table 2. The course of Sperythrozoon infection in clinical and subclinical cases of "ictero-anemia".

Group	Date	Temp.	Days elapsed since initial symptoms	Degree of <u>Sperythrozoon</u> infection	Anemic changes in blood film
Herd A					
Fig 1	7-23	106.0	2	Numerous	Frequent
	25	103.8	4	Frequent	Marked
	29	103.0	8	Scarce	Nearly normal
Fig 2	7-22	106.2	4	Scarce	Marked
	24	105.0	6	Negative	Marked
	8-1	103.0	13	Negative	Nearly normal
Fig 3	7-24	105.5	Apparently normal	Scarce	Marked
	8-1	103.5	Apparently normal	Rare	Nearly normal
Fig 4	7-24	107.0	Apparently normal	Numerous	Normal
	8-1	103.6	Apparently normal	Rare	Marked
Fig 5	7-24	106.7	1	Very numerous	Normal
	26		Dead	(lesions of "ictero-anemia")	
Herd B					
Fig 6	8-19	107.2	1	Very numerous	Normal
	23	107.0	5	Occasional	Marked
Fig 7	8-19	106.0	1	Numerous	Normal
	23	104.5	5	Rare	Marked
Fig 8	8-19	104.5	Apparently normal	Rare	Frequent
Fig 9	8-19	103.5	Apparently normal	Occasional	Normal

Table 2. (concl.)

Group :	Date :	Temp. :	Days elapsed since :	Degree of Eperythrozoon infection :	Anemic changes in blood film :
:	:	:	initial symptoms :	:	:
Herd C					
Pig 10	8- 4	105.0	Apparently normal.	Numerous	Normal
	10	104.6	Apparently normal	Scarce	Marked
Pig 11	8- 4	105.8	Apparently normal.	Frequent	Normal
	10	103.7	Apparently normal	Scarce	Nearly normal
Pig 12	8- 2	103.1	5	Rare	Marked
	8	102.9	11	Rare	Marked
	10	105.0	13	Negative	Frequent
Herd D					
	1950				
Pig 13	2-11	105.6	4	Occasional	Frequent
	16	101.9	9	Rare	Marked
	20	101.0	13	Rare	Frequent

pounds. No Eperythroozoon parasites were observed in any of the smears. The number of latent carriers was, of course, not determined by this method.

EXPERIMENTAL STUDIES

Experimental Procedure

Field observations suggested that the possibility of producing acute, experimental eperythroozonosis in normal swine is quite remote, since it was indicated that a majority of swine may pass through mild infections with no ill effects.

It is known in connection with various blood parasitic diseases, including the genus Eperythroozoon, that the removal of the spleen increases the animal's susceptibility to the disease. Marmorston (1935) summarized the various diseases in which the spleen plays an important part in the immunity. Splenectomized swine were, therefore, used to study experimentally the effects of severe infections of E. suis. It was found that by this method intense parasitic infections could be obtained equalling those that previously had been observed only in field cases.

Ten pigs varying in weight from 45 to 125 pounds were used in these experiments. Four were known to be carriers of E. suis prior to splenectomy; one (pig 1, cholera immune) had recovered from a natural field infection of "ictero-anemia"; two (cholera susceptible) were injected with blood from this pig, and developed a mild Eperythroozoon infection; a third pig (cholera sus-

ceptible) was found to be harboring E. suis derived from an apparently natural source. All four pigs developed acute eperythrozoonosis following splenectomy. Six additional pigs (cholera immune) of unknown carrier status were splenectomized and observed for a period of at least 30 days following the operation in order to determine the presence or absence of latent infection. It was demonstrated in these animals that the removal of the spleen alone resulted in no anemia or clinical symptoms. Five of these pigs were negative for E. suis following splenectomy, and remained normal for at least thirty days. One animal remained normal until experimentally infected with E. suis 82 days after being splenectomized.

Experimental transmission of Eperythrozoon was accomplished in the susceptible pigs by intravenous injection of citrated carrier blood, pig 1 (the recovered field case) serving as the latent carrier of E. suis. A standard inoculating dose of four cubic centimeters of blood was used. Stained blood film examinations were made and temperatures taken at 48 hour intervals following splenectomy to establish the presence or absence of latent infection. The same observations were made daily following inoculation of susceptible pigs in order to determine more accurately the period of incubation. Laboratory determination of blood values was begun in each case upon the first observation of eperythrozoon, and continued daily throughout the course of the disease.

Differentiation of Eperythroozoon Species

The presence of two separate Eperythroozoon species in swine was indicated early in these experimental studies. Following splenectomy, pigs of unknown carrier status relapsed with an organism differing in morphology and pathogenicity from the parasite previously observed in field cases of "ictero-anemia". Cross inoculation experiments further established the two organisms as individual species.

Four splenectomized pigs which had relapsed with E. parvum, only, with no ill effects were injected with blood from a known carrier of E. suis. E. suis appeared in all four pigs after an incubation period of from two to five days. Acute eperythroozonosis was evidenced in each animal, two of which subsequently succumbed to the infection. Conversely, two pigs that had recovered from acute, clinical infection with E. suis were infected with E. parvum. A mild infection occurred after incubation periods of seven and ten days. One pig known to be susceptible to both parasites was infected with both upon experimental inoculation.

The two swine species were differentiated from E. wenyoni and E. ovis by inoculation of heavily infected blood into a susceptible calf and lamb. Both animals remained negative for 30 days. The susceptibility of each to its individual Eperythroozoon species then was proved by injection of known carrier blood. Conversely, an Eperythroozoon susceptible pig was injected intravenously with four cubic centimeters of heavily infected cattle and sheep blood which had been pooled in equal amounts. The pig

remained free of parasites until experimentally infected with both E. suis and K. parvum 58 days later.

Differentiation of the swine species from E. coccoides and E. varians was accomplished by intraperitoneal injection into mice with blood heavily infected with the swine parasites. One Swiss white mouse and two local white-footed deer mice of the species Peromyscus maniculatus were used, the animals having been proved susceptible following splenectomy.¹ All three remained negative for 30 days. Differentiation from E. dispar of the vole was not undertaken. The failure to infect closely related rodents would suggest that the Eperythroozoon species of swine are not closely related to E. dispar.

Morphology

Eperythroozoon suis. As previously stated this parasite is similar in appearance to other species of Eperythroozoon. The principal structure of this extracellular parasite is a delicate ring averaging from 0.5 to 0.8 microns in diameter, and is situated upon the erythrocyte or free in the plasma. Coccus, rod, and budding forms are also observed. At the height of the parasitic attack there are present in great numbers large ring and discoid forms varying in size from one to two and one-half microns. Many of the large ring forms are of distorted shapes, and

1. Identification by Dr. H. T. Gier, Department of Zoology, Kansas State College.

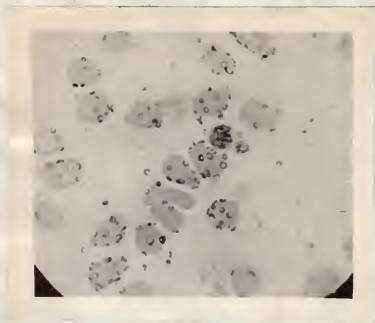


Fig. 1. Ring forms of Eperythrozoon suis located upon the erythrocytes.

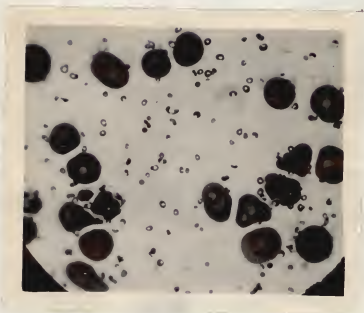


Fig. 2. Extracellular forms of Eperythrozoon suis.

exhibit an irregular distribution of the chromatin at various points on the ring. The discoid forms are seen as flat, solid, chromatin masses. Some erythrocytes are given a vacuole-like appearance from ring forms in which the central clear area of the structure appears to extend completely through the red cell. The parasites may be so numerous as to cover the erythrocytes completely.

Marked morphological changes occurred consistently in citrated or oxalated blood. These changes took place within one minute after mixing with the anti-coagulant, and increased somewhat after further time. While ring forms are the predominating structure in immediate smears, coccus and rod forms predominated in citrated or oxalated samples. The stained organism from samples so treated assumed an appearance similar to Bartonella.

Eperythrozoon parvum. This extra-cellular parasite is observed primarily as small coccus forms and occasional ring structures. The rings average about 0.5 microns in diameter while the coccus forms are somewhat smaller. Accurate measurements of the cocci have not been made. This parasite exhibits a tendency to accumulate in large numbers upon individual erythrocytes, even when very rare in the blood smear.

Pathogenesis and Symptoms

Splenectomized pigs heavily infected with E. parvum evidenced no temperature rise or other visible symptoms. A mild reduc-

tion in blood count (about two million cells per cu mm) with regenerative blood changes was observed in two pigs, while the blood values remained unchanged in three others. One unoperated pig exhibited a mild parasitic infection following inoculation. It appears that this organism is relatively non-pathogenic.

A serious or fatal ictero-anemia resulted in all experimental pigs in which initial parasitic attacks of E. suis were allowed to proceed without treatment. Parasites could be demonstrated in blood smears from two to five days following the inoculation of susceptible animals or splenectomy of known carriers. An extremely rapid rate of multiplication was observed in most cases.

The time from experimental inoculation or relapse from splenectomy to the first appearance of clinical symptoms varied from six to ten days. Increased temperatures to 104.0°F. or 107.0°F. were observed when the parasites became numerous, and continued until spontaneous reduction of the parasites ensued or death occurred. Clinical symptoms became evident on the second or third day in which the parasites had been very numerous. Fever, depression, and inappetence were the early symptoms associated with intense parasitic infections.

Blood values began to fall at this point, and normoblasts appeared in stained smears. Red cell counts dropped one or two million cells per cu mm per day. A spontaneous reduction in the number of parasites usually occurred during the development of acute anemia, and a corresponding decline in temperature to normal or subnormal occurred. The animals were weak and gaunt,

and exhibited symptoms of dyspnea on forced exercise, constipation with bile stained feces, and anemic, icteric mucous membranes.

Erythrocyte counts reached a low of from one to two million cells per cu mm. A low count of 685,000 was observed in one animal immediately prior to death. Hemoglobin values reduced to a minimum of two to four grams per 100 cc of blood, and packed erythrocyte volumes fell to four or seven per cent. An icteric index of from 18 to 25 was observed during acute blood destruction. White cell counts usually remained unchanged, however a marked leukocytosis was observed in several cases. Immature erythrocytes appeared in increasing numbers as the anemia developed, and were most numerous during the period of convalescence.

Spontaneous agglutination of the erythrocytes (observed by Doyle, 1932 and Robb, 1943 in "ictero-anemia") was noted in all experimental cases, and was usually associated with the period of acute anemia. At this time blood sedimentation rates were extremely rapid. Sedimentation of 75 mm in one minute complete to 85 mm in five minutes was observed.

Repeated parasitic attacks occurred in splenectomized pigs, with each attack repeating the course of the disease as described above. After the second or third attack the parasitic invasions were usually of shorter duration and of less intensity. The corresponding symptoms and blood damage also decreased. In these experiments four animals died of acute eperythrozoonosis. Death occurred in from one to five days following the appearance of

Table 3. The course of acute eperythrozoonosis in a susceptible, splenectomized pig.

Days elapsed:	Temp.:	RBC.	Hb.:	Vol.:	Degree of Anemic changes:	Remarks
:	:	:	:	%:	Eperythrozoon:	
:	:	:	:	:	infection:	
:	:	:	:	:	blood film:	
0	102.0	6,500,000	12.1	28	Negative	Normal
2	102.7	7,390,000	11.7	29	Rare	Normal
4	100.9	6,160,000	11.1	26	Occasional	Normal
7	100.0	7,450,000	12.8	28	Frequent	Normal
8	105.7	6,820,000	11.5	28	Numerous	Normal
9	106.6	4,700,000	9.9	20	Very numerous	Normal
10	106.3	4,370,000	9.1	18	Very numerous	Normoblasts
11	105.6	3,570,000	7.1	13	Extremely numerous	Occasional
12	104.4	2,770,000	5.8	12	Extremely numerous	Occasional
13	103.4	2,560,000	4.7	7	Frequent	Frequent
14	102.8	2,280,000	4.1	7	Occasional	Marked
15	103.0	2,130,000	5.1	12	Occasional	Marked
17	103.2	2,350,000	4.9	14	Scarce	Numerous
19	102.2	2,090,000	5.9	14	Rare	Frequent
20 - 33	Continued improvement in blood values until second parasitic attack.					

Injected with E. suis carrier blood.

Pig remains normal. Depression.

Anorexia.

Symptoms continued.

Anemic symptoms. Icteric index-10. Constipated, bile-stained feces.

Icteric index-19. Symptoms continued.

Icteric index-5. Eating and improved.

Improved, but weak.

1. Hemoglobin expressed in grams per 100 cc of blood.
2. Determined by observation of stained blood films.

clinical symptoms. Two animals died in initial, untreated parasitic attacks; one animal died in the second attack, the first being successfully treated; and one died in the fourth parasitic recrudescence, the three previous attacks being controlled by treatment. A total of 35 experimental, parasitic attacks of E. suis have been studied.

Recovered animals probably remain permanent carriers. Fig 1, which had recovered from a natural field infection, was proved by subinoculations and finally by splenectomy to have retained E. suis a period of three months. Blood examinations made during the two-month period prior to splenectomy were negative.

Morbid Anatomy

The lesions observed in all four experimental cases that died of acute eperythrozoonosis were identical with those described in field cases of "ictero-anemia". Generalized icterus was present throughout the body fat and tissues. The blood appeared thin and watery. The liver exhibited a yellowish-brown color, and the gall bladder contained a thick, gelatinous bile. The heart and kidneys were pale and flabby. A few petechia were usually present on the mucosal surface of the bladder. The gastrointestinal contents were deeply stained throughout with a yellow-orange bile. Hydro-pericardium and ascites were observed in two pigs, the fluid being a clear, yellow color. Splenic lesions were, of course, not observed in these studies. Bacterial examinations of tissue were negative.

Microscopically the principal changes were observed in the liver. The severity of the lesions varied from mildly retrogressive changes to a marked atrophy and necrosis of the central hepatic cells. Varying amounts of hemosiderin and some lymphocytic infiltration were present in all. Parenchymatous and fatty degenerative changes of the hepatic cells were present in all. One field case examined also showed a severe central necrosis. Spencer (1940) described similar microscopic lesions in field cases of "ictero-anemia". The kidneys showed relatively little change other than parenchymatous degeneration. No significant microscopic lesions were observed in any of the other tissues examined. Eperythrozoon parasites could not be distinguished in tissue sections prepared with either hematoxylin-eosin or Giemsa stains.

Prevalence, Transmission, and Relation to Hog Cholera

Field observations suggested that Eperythrozoon infection in swine is probably quite common. Additional opportunities were afforded in these experimental studies to determine the prevalence of E. suis and E. parvum in this locality.

Six of the experimental pigs obtained from a single herd had been exposed to sows and older pigs in the herd for a period of from June to August. As shown by splenectomy four were carriers of E. parvum, one a carrier of both E. parvum and E. suis, and one pig was negative. The known susceptible pig was infected with both species following inoculation of pooled blood obtained

from five pigs selected at random at a local livestock sales pavilion. These five pigs represented five separate herds. The animals varied from 40 to 200 pounds in weight.

Relatively little information is available as to the exact modes of transmission of Eperythrozoon species. Eliot (1936) succeeded in transmitting E. coccoides with the louse, Polyplax serrata. Jensen (1943) observed rapid transmission of E. wenyonii when susceptible calves were exposed to carriers in the presence of large numbers of biting flies. Eperythrozoon transmission in swine is, in all probability, effected by biting arthropods. This is indicated also by the seasonal occurrence of the majority of cases of "ictero-anemia" in swine.

Quin (1938) and Spencer (1940) noted that a rather significant number of cases of "ictero-anemia" follow in two to six weeks after herd serum and virus vaccination for hog cholera. An experiment was conducted to determine the possible transmission of E. suis in hog cholera virus. Blood heavily infected with eperythrozoa was defibrinated, and phenolized to contain 0.5 per cent phenol. A phenol solution standardized by the Bureau of Animal Industry to a content of 5 per cent was used in securing the proper dilution. The treated blood was held at a temperature of 37°F. for 15 days. Four cubic centimeters was then injected intravenously into a susceptible, splenectomized pig. The pig remained negative for 30 days, and then was infected with virulent carrier blood.

From this experiment it appears unlikely that Eperythrozoon transmission occurs through the use of phenolized virus blood.

Mechanical transmission from carrier to susceptible pigs may, presumably, occur by means of vaccination needles used in serum and virus injections. It would appear, however, that most cases of post-vaccinal "ictero-anemia" are the result of natural infection occurring coincidentally to the vaccination, rather than from mechanical infection at the time of immunization. This is indicated primarily by the occurrence of such cases only during seasons in which relatively rapid transmission is to be expected from insect vectors. The disease has not been reported following vaccination or other surgical procedures during the winter months. Lowered resistance of the animal during the hog cholera virus reaction, described by McBryde (1942), possibly may allow the parasite to increase to pathogenic numbers in a larger number of pigs naturally infected during this period.

The effects of hog cholera virus reaction coincident to the fever and anemia of subclinical eperythrozoonosis are unknown. If "breaks" can occur under such conditions, in all probability, they are confined in most cases to a relatively few animals in the herd. Campbell (1945) found that "ictero-anemia" may incur heavy losses when complicating swine erysipelas or hog cholera.

Chemotherapy

The specific action of arsenical compounds in Eperythrozoon infections, as demonstrated by Neitz (1937) and others, prompted investigations of specific therapy against E. suis. The experimental chemotherapy of acute eperythrozoonosis of swine was con-

ducted with neocarsphenamine because of the availability of this drug. The detailed effects of various intravenous dosages upon heavy infections of E. suis are shown in Table 4. Specific action was obtained in single intravenous injections at a dosage varying from 15 mg/kg to 45 mg/kg, quicker action being obtained with the larger doses. Parasites were removed completely from the blood or reduced to non-pathogenic numbers in from 2 to 24 hours following initial therapeutic doses.

Most parasitic attacks were treated within 24 to 72 hours after the animal had exhibited clinical symptoms. Two were treated prior to clinical symptoms, and did not develop visible evidence of the disease. The clinical condition and body temperatures returned to normal within 24 hours following effective therapeutic doses. Some weakness remained in those individuals in which blood values were considerably lowered by delayed treatment. Blood destruction was halted almost immediately in most cases by the removal of E. suis.

Spontaneous relapses occurred in nearly all of these splenectomized animals, and were usually re-treated with neocarsphenamine. An increased resistance to repeated treatment was evidenced by E. suis in several animals. In pig 73 a marked resistance was developed following an initial dose of 5 mg/kg, which temporarily reduced the number of parasites. In two subsequent attacks single therapeutic doses had no effect, and additional injections were required to produce action.

In one case, pig 2, sodium cacodylate was injected intravenously at a rate of 0.3 grain per pound of body weight. The

Table 4. The results of single, intravenous doses of nearsphenamine upon pigs undergoing acute, parasitic attacks with Eperythrozoon suis.

Parasitic attack no.:	Dose:	Degree of infection	Before injection:		After injection:		RBC reduced ² in days	Parasitic relapse in days	
			1 hr.:	2 hrs.:	6 hrs.:	24 hrs.:			
72	45	Very numerous	Rare	Negative	Negative	Negative	4.98	4.68	11
	2nd	Untreated					4.84	1.02	Died
1	40	Very numerous	Numerous	Scarce	Rare	Negative	6.75	5.65	None
67	20	Very numerous	Numerous	Numerous	Rare	Rare	3.69	3.10	5
	2nd	15	Numerous	Numerous	Numerous	Frequent	4.03	1.20	8
	3rd	Untreated					2.18	1.26	
2	20	Very numerous	Very numerous	Very numerous	Very numerous	Scarce	4.36	3.80	None
60	15	Very numerous	Occasional	Scarce	Rare	Negative	3.66	3.88	6
	2nd	12.5	Numerous	Frequent	Occasional	Rare	3.55	2.80	3
	3rd	Untreated					3.64	2.44	27
	4th	15	Numerous	Numerous	Frequent	Occasional	2.86	3.58	
73	5	Very numerous	Very numerous	Very numerous	Very numerous	Numerous	4.72	4.04	4
	2nd	25	Extrem. numerous	Extrem. numerous	Extrem. numerous	Extrem. numerous	3.28		
	25	Extrem. numerous	Extrem. numerous	Extrem. numerous	Extrem. numerous	Rare		1.99	5
	30	Extrem. numerous	Extrem. numerous	Extrem. numerous	Extrem. numerous	Very numerous		2.75	
	20	Extrem. numerous	Extrem. numerous	Extrem. numerous	Extrem. numerous	Numerous		1.79	5
	Untreated	Numerous	Numerous	Occasional	Scarce	Negative	3.08	0.68	Died

1. Dose expressed in milligrams per kilograms of body weight.
2. Erythrocytes expressed in millions of cells per cu mm. Figures indicate the count at the beginning of treatment, and the lowest count observed following therapy.

parasites increased rather than decreased during the following 72 hour period. The infection was controlled immediately with neocarsphenamine.

These experiments indicate that neocarsphenamine and probably other drugs specific for Eperythrozoon should prove of value in field cases of acute eperythrozoonosis. It is obvious that such treatment will be of little or no value if delayed until spontaneous reduction of the parasites and severe blood damage have occurred. It is not expected that severe, spontaneous attacks will re-occur following specific therapy of unoperated swine; however such determination can be made only by treatment of field cases.

DISCUSSION

The observation of a blood parasite associated with the "anaplasmosis-like disease" of swine immediately suggested that the organism might be the etiological agent of the disease. Kinsley (1932), Doyle (1932), Dicke (1934), and Doyle (1945) also observed similar parasites connected with the disease, but apparently made no attempts to identify the organisms observed. It has been recognized, however, that this disease is typical of the condition produced by blood protozoa (Anaplasma, Piroplasma, Bartonella, and etc.).

"Ictero-anemia" is known to be a disease of sporadic occurrence. However, these studies indicated that E. suis is a common blood parasite of swine in this region. It was evident, there-

fore, that the observation of the parasite in affected animals could not be considered final proof that the organism was responsible for the pathological processes observed.

Data was gathered from field cases in a manner in which observations could be made on the relationship of the Eperythrozoon infection to the course of the "anaplasmosis-like disease". The experimental reproduction of acute eperythrozoonosis enabled a comparison to be made of the disease process and pathology known to be caused by E. suis with the disease process and pathology of field cases thought to be due to E. suis.

In correlating the parasitic infection with the course of the disease, the observation by Neitz and co-workers (1934) concerning the course of acute eperythrozoonosis of sheep is of particular significance. They found that the active multiplication of eperythrozoes continued up to the time when the first signs of anemia made their appearance in smears. Then the number suddenly decreased so that when the anemia was most marked, comparatively few or no organisms could be seen.

This characteristic disease course was found to be typical of acute, experimental infections with E. suis (illustrated in detail in Table 3). In addition increased temperatures were found to be directly related to the degree of parasitic infection. High temperatures coincided with heavy infections, and decreased as the parasites disappeared.

In comparing this characteristic disease course of acute, experimental eperythrozoonosis to the data obtained in field cases of "ictero-anemia" (Table 2), it will be noted that the

disease processes are identical. Data obtained on pigs 1,4,6,7, 10, and 11 which apparently were observed at or near the peak of parasitic infection, illustrate the course of acute eperythrozoonosis as described. Temperatures were increased early in the disease when the parasites were most numerous, and usually decreased as the parasites disappeared. A rapid decrease in the number of parasites was also correlated with the development of an anemic blood picture, the parasites being few or absent during marked anemic changes in the smear.

Additional evidence of etiology is indicated in the degree of parasitic infection. Heavy parasitic attacks of E. suis in experimental animals approximated the intensity of parasitic attacks observed in field cases of "ictero-anemia". The symptoms and course of the disease following attacks in these two groups of animals were identical. Mild parasitic attacks were observed in both experimental and field cases. These attacks resulted in subclinical or no symptoms. Stated in other words, the development of a disease process in both experimental and field cases depended directly upon the number of parasites present in the parasitic attack.

Further indication that "ictero-anemia" is identical to acute eperythrozoonosis is the identical pathology of each. However, it is not intended to imply that this can be considered proof of etiology alone, since various blood parasites of animals produce similar pathological changes.

The basis for establishing the parasite, E. suis, as the etiological agent of "ictero-anemia" then lies in the fact that

the disease was reproduced in experimental swine by the inoculation of infectious material from field cases. The resulting symptoms, disease course, and pathology were identical with the field cases.

From the observations made in these studies and information available concerning other species of Eperythrozoon, a number of puzzling aspects of the "anaplasmosis-like disease" of swine are apparent.

Eperythrozoon suis is a common blood parasite of swine. The majority of older animals, in all probability have been exposed and infected when young, and remain permanently immune, latent carriers. Clinical cases usually are encountered, therefore only in young susceptible swine which are exposed to infection from carriers. A strictly seasonal occurrence is indicative of insect transmission, as would be expected with the available information concerning the Eperythrozoon species. The clinical cases occur in an insignificant number of the animals actually infected. Depending upon the intensity and duration of the parasitic attack, clinical, subclinical, or no symptoms may appear. The majority of animals are capable of suppressing the multiplication of the parasite, and as a result no blood damage or other ill effects are incurred. Because of this wide variation in severity, it would seem that the clinical condition is more commonly encountered than generally recognized, particularly in cases in which blood destruction has not been excessive and prompt recovery occurs. Experimental cases that undergo intense attacks of short duration develop symptoms lasting only a day or two

during this particular period. Immediate improvement is evidenced upon the spontaneous reduction of the organisms, and the animals are eating and active during the mild anemic stage.

The inability of previous investigators to establish the etiology of this disease may be attributed to a number of reasons. The failure to use splenectomized swine in transmission attempts undoubtedly has been the primary reason. The failure of investigators to identify blood parasites observed in connection with the disease has been another. The characteristic reduction and disappearance of the parasite during the development of the acute anemic stage most certainly adds to the difficulty in diagnosis. Needless to say, good staining technique is essential for the observation of the parasites. Heavy infections may easily be overlooked in slides stained in slightly excessive acid or alkaline solutions, or lightly stained with Wright's stain.

E. suis is apparently the first species of this genus to be incriminated as producing a clinical disease entity in naturally infected animals under field conditions. As previously stated, it has been determined that the severity of the disease depends upon the number of parasites present in the blood and the duration of their presence. However, these studies have not explained why certain individual animals or groups of animals are unable to suppress the multiplication of the parasites while the majority of animals successfully inhibit its growth.

In general terms the reason may be advanced that these certain individuals possess a lowered resistance to this parasite. There has been no evidence to indicate that the quantity of or-

ganisms introduced materially influences the severity of the disease or that there is a noticeable difference in the virulence of strains of E. suis. The factors which operate to influence this susceptibility are unknown. They may be inherent in certain individuals or derived from external sources. Marshfield (1949) has reported the observation that nutritional anemia in young pigs may be followed later by "ictero-anemia". Additional investigations will be required to determine what factors are necessary to predispose normal, susceptible swine to acute eperythrozoonosis.

The question arises why acute eperythrozoonosis has not been observed in field cases in cattle and sheep, since it is apparent that these animals commonly harbor Eperythrozoon. Neitz (1937) and Jensen (1943) demonstrated experimentally that E. ovis may produce an acute, febrile anemia in unoperated sheep. Icterus was not particularly prominent. It does not seem improbable that acute field infections may occasionally be observed in individual sheep and the anemia attributed to gastro-intestinal parasites, improper nutrition, or other causes.

There is no evidence at the present to indicate that clinical symptoms of acute eperythrozoonosis may be observed in normal, susceptible cattle. Neitz (1940) observed mild parasitic infections when susceptible, unoperated cattle were infected with E. wenyonii. Heavy parasitic infections in splenectomized calves may result in a moderate to severe anemia, according to Neitz (1940) and Jensen (1943).

In the author's observations E. suis, in heavy infections,

has evidenced a much greater and a more constant ability to bring about clinical symptoms and severe blood damage than either E. ovis or E. wenyoni. In 21 acute parasitic attacks studied in splenectomized cattle and four studied in unoperated sheep the two latter species of Eperythrozoon produced variable degrees of anemia, and clinical symptoms varying from none to severe. In the majority of cases clinical symptoms were absent, and the anemia mild. On the other hand, equally intense infections of E. suis invariably resulted in clinical symptoms and severe blood damage in untreated swine. It is the author's opinion that acute eperythrozoonosis is much more likely to be encountered in field cases in swine than in either sheep or cattle, because of the greater pathogenicity of E. suis in heavy infections.

SUMMARY

A blood parasite of the genus Eperythrozoon was observed in eight field outbreaks of the clinical entity of swine known as "ictero-anemia" or "anaplasmosis-like disease". Animal inoculation studies established the organism as a new species to which the name, Eperythrozoon suis, was given. The disease was reproduced in susceptible, splenectomized swine by the inoculation of infectious blood from a field case. The resulting symptoms, disease process, and pathology were identical to field cases. E. suis was found associated with a clinical or subclinical anemia in a total of 21 individual field cases.

The characteristic course of the disease was noted in both field and experimental cases. This consisted of a severe para-

sitic attack in which symptoms of fever, depression, and anorexia were present. Severe and rapid blood destruction quickly followed, and the parasites spontaneously became reduced in numbers. The animals exhibited a lowered temperature, pale and icteric mucous membranes, marked weakness, and constipated bile-stained feces at the onset of acute anemia. Repeated spontaneous relapses occurred in splenectomized swine and repeated the course of the disease as described. A total of 35 acute attacks of E. suis were studied in the experimental investigations.

It was found that the severity of the disease is dependent upon the intensity and duration of the parasitic attack. The disease could not be reproduced in unoperated swine because of mild infections which followed experimental inoculation. Mild parasitic infections were also observed in many of the animals in herds undergoing acute eperythrozoonosis. Parasitic infections, which were equal in intensity to those observed in field cases of acute eperythrozoonosis ("ictero-anemia"), were reproduced experimentally by the use of splenectomized swine. It was indicated that the majority of young swine in enzootic areas undergo infection with E. suis, and usually are unaffected by the mild attack that results. All infected animals probably remain permanent carriers.

The exact mode of transmission is unknown, but is presumed to be by insect vectors. E. suis could not be transmitted in heavily infected blood which was subjected to the same conditions as hog cholera virus blood.

Specific therapy against E. suis was obtained with neocarsphenamine in single, intravenous dosages varying from 15 to

45 mg/kg. An increased resistance to repeated treatment was evidenced by E. suis in several cases. Sodium cacodylate was ineffective at an intravenous dose of 0.3 grain per pound of body weight.

An apparently non-pathogenic blood parasite, designated as Eperythrozoon parvum was observed in the experimental studies. E. suis and E. parvum were both found to be common parasites of swine in this locality.

It is concluded that the disease of swine described in the literature as "ictero-anemia" or "anaplasmosis-like disease" is the result of acute infection with Eperythrozoon suis. Should additional agents be found to produce similar symptoms and pathology, it will be necessary to differentiate these from acute eperythrozoonosis.

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