completely hidden by it and hunting is thereby rendered practically impossible.

While these huge tracts of waste land, where this grass grows, remain untenanted, the elephant and buffalo will therefore still have haunts to which they can retire unmolested by the advance of civilisation.

NOTES ON THE COMMON PATHOGENIC PROTOZOA IN BRITISH EAST AFRICA

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In compiling these elementary notes on some of the more common pathogenic Protozoa, I have endeavoured to epitomise the modern literature, and so offer shortly a crude but, I trust, accurate synopsis of the species from a zoological and pathological point of view.

Knowledge of the Protozoa is so imperfect and is proceeding with such rapid strides that systematic treatment of the subject is well-nigh impossible. In view, however, of the many deadly diseases of animals, and of man too, which are due to this Phylum, much attention has been devoted to its study within recent years. Mention of East Coast Fever, Malaria, and Sleeping Sickness at once indicates the progress that has been effected since the time when Laveran (1880) described the parasite of Malaria and Ross (1893) the life cycle in the mosquito, lays bare our ignorance, and exposes the enormous field of research which must be covered before results, which will materially benefit the position from the zoological or from the practical and commercial point of view, can be achieved.

All the parasites discussed in the following pages are to be encountered in the blood of the affected animal and can be studied in the ordinary film of blood or of organs, stained by one or other of the modifications of Romanowsky's method (Methylene blue—Eosin). No mention is made here of the

flagellated and ciliated organisms parasitic in the intestinal tract of apparently healthy animals, nor of the important genus of the Sporozoa—*Coccidia*—one member of which has been found in association with a serious disease of cattle.

The preliminary classification of the Phylum Protozoa is made on the character of the means of locomotion, four sub-phyla being recognised.

1. *Sarcodina,* a group possessing pseudopodia; includes the *Amoebae,* some of which are pathogenic.

2. *Mastigophora,* in which mobility is due to one or two flagella. The trypanosomes are included in this group, as also are the *Spirochaeta,* though the morphology of the latter affords much scope for debate as to the propriety of their inclusion here.

3. *Infusoria.* Ciliated forms, none of which are credited with serious pathogenic powers.

4. *Sporozoa,* a group devoid of motile organs. To this sub-phylum belong the greatest number of pathogenic genera. It is a particularly interesting group on account of the complicated life cycle undergone by all described species, and owing to the necessity, in many cases, for a second host in which to complete development, and which acts as a reservoir or a transmitter for the maintenance of the race.

Mastigophora and Sporozoa alone call for attention here: the more important species which are parasitic upon and pathogenic to domestic animals, or which have come prominently under the notice of this Laboratory, are the only ones which will be discussed.

SUB-PHYLUM, *Mastigophora.* Diesing.
CLASS, *Lissoflagellata.*
ORDER, *Spirochaetida.*
GENUS, *Spirochaeta.* Ehrenberg, 1833.

The question as to whether the Spirochaeta should be placed among the Bacteria in the vegetable kingdom, or in the Protozoa, is still discussed. At the present moment the consensus of opinion lies with the view that they should be grouped as Protozoa.

Species.

Sp. Theileri. Laveran, 1903.

Hosts. Cattle.

Distribution. This parasite was first found in the Transvaal. It has been found in cattle in East Africa.

Morphology. Sp. Theileri measures from 20μ to 30μ in length, and rather over 1μ in thickness. The number of curves is variable, being on an average about 8 to 10.

Transmission. Laveran and Vallée succeeded in infecting a cow in Paris with the larvae of the South African Blue Tick (*Boophilus decoloratus*) sent from Pretoria. Theiler's first attempt to reproduce infection by the inoculation of blood was negative. Subsequent experiments, however, have shown that the parasite can be transmitted in this manner.

Pathogenesis. Little is known of the disease caused by this parasite. In South Africa it is associated with one of the forms popularly referred to as 'Gall Sickness.' In East Africa it has been found in cattle which are manifesting a pronounced anæmia. The blood of an animal which has recovered from the disease still contains the parasite, though it may not be detectable under the microscope, and such an animal may serve as a reservoir for the transmitting tick.

Spirochaeta have also been found in the horse (*Sp. equi*) and in the sheep (*Sp. ovina*) in Africa. Stordy was the first to describe the former in East Africa. The latter is said to be fairly common in Erythrea and Abyssinia. Nothing is known as to the transmission of these species.

Sp. gallinarum. R. Blanchard.

Hosts. Domestic fowls, also in pigeons, geese and ducks.

Morphology. Measures about 20μ in length.

Transmission is effected by means of one of the ticks belonging to the sub-family *Argasidæ*. The appearance and habits of these ticks are dissimilar to the commonly known species. In shape they are more like a wood louse, and in habits they are mainly nocturnal. They usually attach themselves to an animal for a few hours, during which time they feed, and then drop off and retreat to a hole or crevice in

the mud, wood work or masonry of the infected building. They are rarely found in the open. *Argus miniatus* is responsible for the transmission of this disease in South America, and *Argus persicus* in Northern India. It is possible that the closely allied genus *Ornithodorus* which is represented in Uganda and East Africa by *O. moubata* (the tick carrying the Spirillum fever of man) may also serve as a carrier.

Pathogenesis. *Sp. gallinarum* is the cause of serious epidemics among poultry, especially imported birds, in Brazil and India. The disease is very rapid and fatal in most outbreaks, the discovery of dead birds being frequently the first indication of its existence.[1]

Distribution. South America (Brazil), India, Soudan, Southern Rhodesia, Australia. I have seen one case of a bird dead in Nairobi, which showed *Spirochaeta*, possibly this species. The existence of *Sp. gallinarum* to our north and south renders it the more probable that it occurs in this Protectorate.

The family *Spirochaetida* also includes the species *Treponema pallida*, the cause of Syphilis, and *Sp. duttoni*, the cause of human relapsing fever in Africa or Uganda tick fever. It is in connexion with these diseases that Ehrlich and Hatta have introduced the drug (Diamino-dioxy-arsenobenzol) more popularly known as '606,' the curative action of which, so far as at present ascertained, may almost be considered specific. As a preventive it is probably of less avail.

ORDER, *Trypanosomatida.*
GENUS, *Trypanosoma.* Gruby, 1843.

The species found in mammals of this Protectorate have not yet been defined, but it appears probable that at least four must be recognised :—

T. gambiense.	Dutton.	*T. vivax.*	Ziemann.
T. dimorphon.	Dutton & Todd.	*T. lewesi.*	Kent.

Additional observations will no doubt declare the existence of members of the genus in birds and fish.

[1] See *Wellcome Research Lab. Reports*, vol. ii., for description of disease among fowls in Soudan caused by this or an allied *Spirochaeta*.

T. gambiense. Dutton, 1902. The parasite of sleeping sickness or trypanosome fever in man.

Distribution. In East Africa it is confined to the vicinity of Lake Victoria and a few of the larger tributary rivers.

Hosts. Man; probably cattle and game (Bruce, Hammerton, Bateman, and Mackie); *Glossina palpalis.*

Morphology. Average length about 18μ to 25μ, breadth 1·4μ to 2μ with a free flagellum of 5μ to 7μ.

Biology. Capable of development in most domestic animals and the smaller laboratory species as rats, guinea-pigs, and rabbits. Duration of disease in these species usually long, and trypanosomes scanty in the blood. Culture *in vitro* has only been partly successful.

Transmission. The coincidence of *T. gambiense* and *Glossina palpalis* led to the view that this fly is a specific host, and Bruce and Nabarro showed that infection could be transmitted by its agency. The work of Kleine, and subsequently that of Bruce, Hammerton, Bateman, and Mackie, has shown that a developmental cycle must take place in the fly, since a period of at least sixteen days elapses between the time the trypanosomes are ingested with the blood and the period when the fly becomes infective. This infectivity once established may last at least fifty days. Owing to the frequent presence of flagellates peculiar to the tsetse flies, as, for example, *Trypanosoma* or *Herpetomonas grayi,* the developmental forms of which in the gut cause much confusion, details of the cycle of *T. gambiense* have not been clearly made out.

Prior to the discovery of this true cyclical development all successful transmission experiments had been of a mechanical nature, i.e. the trypanosome was presumably conveyed from the sick to the healthy animal on the proboscis. Such transmission might in theory be effected by any biting fly, and Nabarro and Greig proved that flies (*Gl. fusca, Gl. longipennis, Gl. pallidipes*) caught at Kibwezi in this Protectorate could transmit infection eight hours and twenty-four hours after the infecting meal.

Recently a number of cases of human Trypanosomiasis have been found in the Loangwa Valley, Northern Rhodesia, where no *Gl. palpalis* have yet been discovered despite careful and

prolonged search. *Glossina morsitans* is very prevalent in this valley, and *Gl. fusca* also occurs, and these species are to be incriminated until their innocence be proved.

It is highly imperative that experiments with other biting flies and with *Tryp. gambiense* should be conducted in order to confirm the observation of Kleine that *Gl. morsitans* does not act as a definite host. Stephens has suggested that the human trypanosome of Northern Rhodesia is not *T. gambiense*, but a new species which he calls *T. rhodesiense*. If this be substantiated the transmission by flies other than *Gl. palpalis* would be explained.

Trypanosoma dimorphon. Dutton and Todd, 1903. A parasite of domestic animals.

Distribution. Originally described from the Gambia, this —or allied and confused species—has since been shown to be widely distributed in Africa. I have specimens from Mambrui near Malindi, which are morphologically indistinguishable.

Hosts. Horses, cattle, sheep, goats, dogs and possibly pigs.

Morphology. The original description of Dutton and Todd defines the species as occurring in three forms, i.e. a very short or 'tadpole,' a medium or 'stumpy,' and a 'long' form which carries a free flagellum. In the strain brought to Europe, Laveran and Mesnil, and Thomas and Breinl failed to find the free flagellated forms. Considerable confusion has resulted from this dual description, and species not answering to type have been recorded as *T. dimorphon*. The strain carried to Europe was not that studied by Dutton and Todd, and it is consequently most probable that it represents a distinct species for which the name *T. confusum*, Montgomery and Kinghorn, was suggested. 'Tadpole' forms measure from 11μ to 13μ, 'Stumpy' forms 16μ to 20μ, and the 'Long' forms vary from 15μ to 30μ, of which 5μ to 10μ is taken up by the free flagellum. It is usual for 'Tadpole' forms to predominate during the earlier period of disease; the long free flagellated forms becoming numerous only towards death.

The differential diagnosis of *T. dimorphon* from species

presenting affinities is difficult unless the original description of Dutton and Todd be borne in mind. It is necessary for a trypanosome to manifest all these three morphological forms before it can be accepted as of this species. The following list embraces the species most liable to be confused with *T. dimorphon*: *T. congolense*, Broden; *T. pecaudi*, Laveran; *T. confusum*, Montgomery and Kinghorn (a name given to the species maintained at Liverpool and Paris as *T. dimorphon*, the name is pre-occupied by Luke, 1906); *T. montgomerei*, Laveran; *T. nanum*, Laveran. Of these *T. pecaudi* alone manifests a free flagellum, but it may be distinguished from *T. dimorphon* by the fact that forms similar to the 'Tadpole' are not found.

Biology. Capable of development in all Laboratory animals. Man appears to be insusceptible. Culture *in vitro* has been realised.

Transmission. The confusion which has occurred with this species renders much of the evidence on transmission in nature of small value. Trypanosomes of the *dimorphon* group have been transmitted by *Gl. palpalis* (Roubard and Bouet). Bruce, Hammerton, Bateman, and Mackie have shown that the form they found in Uganda undergoes cyclical development in this fly.

The writer found a trypanosome in Northern Rhodesia which responded in all details to the original description of Dutton and Todd. In this locality *Gl. palpalis* is absent. *Gl. morsitans* exists and is the species locally incriminated. From circumstantial evidence, the genus *Stomoxys*, sp. incert., was blamed and subsequent evidence has indicated that this or neighbouring species of trypanosomes can be spread in localities where *Glossinae* have not been found. It is interesting to note that no tsetse flies have been found in the locality of Mambrui from whence my preparation comes. This very important question is still *sub judice*, but we have knowledge that the genus *Stomoxys* can spread Trypanosomiasis. Martin, Leboeuf, and Roubard have succeeded in transmitting *T. brucei* by means of *S. calcitrans* and *S. glauca*.

Since the year 1902 the island of Mauritius has suffered severely from the ravages of Surra (*T. evansi*), which was

introduced in cattle from India towards the end of 1901. In 1903, 2251 head of cattle and 965 equines died of this disease, which in Mauritius is spread by the agency of *Stomoxys geniculatus*.

Trypanosoma vivax. Ziemann.

Distribution. Probably widely distributed in Africa. It is known in the Cameroons, in Northern Rhodesia, and in Uganda, and a form found in Italian Somaliland is possibly of this species. Laveran has created *T. cazalboui* for a trypanosome very closely allied. Its existence in East Africa is only suspected; parasites seen in preparations of ox blood sent by Mr. A. G. Doherty, the Veterinary Officer stationed at Marsabit, towards the Abyssinian frontier, being morphologically very similar.

Hosts. Cattle. Other domestic ruminants are susceptible. Dogs, rabbits, guinea-pigs are immune.

Morphology. Stained preparations measure from 20μ to 26μ in length and from 2μ to 3·5μ in breadth at the widest part. The posterior end is commonly bluntly rounded, and shows a well-defined kinetonucleus. The undulating membrane is poorly developed, being represented by a narrow structure which shows very slight tendency to fold. The free flagellum is relatively short, rarely more than 6μ or 7μ in length. In a fresh preparation the movement of this trypanosome is quite distinct from that of most other mammalian forms. Its movement is so rapid and the change in direction so sudden that it is impossible to retain any one organism in the field of vision for more than a very short time.

Biology. The insusceptibility of mice, white rats, guinea-pigs, rabbits, dogs and monkeys is characteristic of the group of trypanosomes which contains *T. vivax*, *T. nanum* and *T. cazalboui*. These laboratory animals are as a rule susceptible to all other mammalian trypanosomes.

Transmission. Ziemann incriminated Tabanidae in the transmission of this species, and Cazalbou has also laid stress on the importance of this family in the spread of the disease 'La Soumaya,' of which the Trypanosome named after him is

the cause. The Italian workers in Erythrea note that there is no tsetse in the affected area and that the suspected fly is a *Tabanus* or a *Hippobosca*.

The Sleeping Sickness Commission of the Royal Society showed that *Gl. palpalis*, caught on the shore of Lake Victoria, was infected with *T. vivax*. Bouffard has shown that *Gl. palpalis*, of the Niger region in French territory, maintains a true cyclical development of this Trypanosome, that it became infected after so short a period as a week, and that it might remain infected for at least two and a half months after the infecting meal.

In Northern Rhodesia no *Gl. palpalis* occurred within 200 miles of where *T. vivax* appeared endemic. *Gl. morsitans* or other genera of biting flies (*Tabanus* and *Stomoxys*) must be incriminated.

Trypanosoma lewesi. Kent, 1881.

Hosts. *Mus rattus*, *Mus decumanus*, and *Mus rufescens*. Lingard, in India, describes it as also occurring in *M. ninieventer*.

Distribution. *T. lewesi* is widely distributed, especially in sewer rats, throughout the world. Stordy has noticed its occurrence in Mombasa, and at Kisumu I found it present in 52 per cent. of the rats examined (November 1909). Bruce and Nabarro found it prevalent at Entebbe.

Morphology. This Trypanosome measures about 25μ in length, including the flagellum, and about 1·5μ in breadth. It is narrower than the free flagellated pathogenic forms—*T. gambiense*, &c.—and the undulating membrane is more poorly developed.

NOTE.—*The term 'flagellated' is used to denote a trypanosome carrying a free flagellum, as opposed to a form (e.g. T. nanum, T. cryolense, tadpole T. dimorphon) which does not. These latter are usually very short trypanosomes and consequently are relatively narrow.*

In a fresh preparation the movement of *T. lewesi* is more rapid than in most other species, but it is not so great as in *T. vivax*.

Biology. No animal species but rats appear susceptible to infection. A transitory infection lasting a few days can be

detected in other rodents, but the trypanosome does not appear to multiply freely. Trypanosomes possessing somewhat similar morphological characteristics, but which are specific for their hosts, have been found in the Rabbit (*T. cuniculi*, Blanchard) and Mouse (*T. duttoni*, Thiroux). Novy and McNeal, who were the first to succeed in the artificial cultivation of trypanosomes, made use of this species and obtained quite vigorous growths on a medium composed of blood-agar.

SUB-PHYLUM, *Sporozoa.*
CLASS, *Telosporidia.* Schaudinn.
ORDER, *Haemosporidia.* Danilewsky.

Minchin divides this order into two sub-orders :—

1. *Haemosporea,* to include the genera *Lankestrella* (Labbé, 1899), *Karyolysis* (Labbé, 1894), and *Haemogregarina* (Danilewsky 1885), all of which are parasites on the red blood corpuscles of cold-blooded vertebrates,—fish, amphibians and reptiles.

2. *Acystosporea.* These forms are parasitic in the red blood corpuscles of warm-blooded mammals and birds, and require a second host, a blood-sucking arthropod, to bring about transmission. It is usual for the parasites to exhibit both a sexual (sporogony) and an asexual (schizogony) mode of development.

Schizogony takes place in the vertebrate host and Sporogony in the arthropod. In many cases the actual stages of development—more especially in Sporogony—have not yet been fully worked out, but the connexions of Malaria with mosquitos, East Coast Fever and Redwater with ticks, will serve as examples of this alternation in generation. The principal genera of the Acystosporea are *Plasmodium* and *Laverania,* which includes the malarial parasites of man and monkeys ; *Haemoproteus* and *Halteridium,* to which the very common parasite of the red blood corpuscles in birds belongs ; and the genera *Babesia, Theileria* and *Nuttallia,* which are parasitic on, or found in, the red blood corpuscles of the domestic animals. We only discuss here the last three genera, all of which in nature require one of the tick family (*Ixodidae*) to effect transmission.

GENUS, *Babesia*. Starcovici, 1893.

SYNONYMS { *Pyrosoma*. Smith and Kilborn, 1893.
Piroplasma. Paton, 1895.

Babesia bigemina. Smith and Kilborn, 1893.

SYN. { *Piroplasma bigeminum*.
Piroplasma bovis.

Hosts. Cattle.

Distribution. First described by Smith and Kilborn, 1893, as the cause of Texas Fever in North America, this parasite has a wide distribution throughout the world and is associated with the disease known as Redwater in cattle. It is probably universally distributed in East Africa.

Morphology. The typical form is a twin pear-shaped body lying within a red blood corpuscle. Each pear measures from 2μ to 4μ in length and about 1μ in breadth at the blunt extremity. Round and irregular forms, measuring from $1{\cdot}5\mu$ to $2{\cdot}5\mu$ in diameter, are also found. Parasites free in the plasma are also encountered. According to the researches of Nuttall and his co-workers on this parasite and on *Babesia canis*, the intra-corpuscular development is simple; the pear-shaped forms becoming round, then ovoid, and finally dividing into two by a process of budding. This Nuttall regards as an essential characteristic of the genus *Babesia*. Certain authors (Doflein, Lignieres, Bowhill) have described flagellated forms as occurring, and regard these as analogous to the microgamete flagellation in other Protozoa.

Transmission is effected by means of a tick. Species of the genus *Boophilus curtis* are mainly responsible, *B. annulatus* in America and *B. decoloratus* (the blue tick) in Africa. This genus of tick requires but one host, that is to say a larva having once reached an animal remains thereon throughout its full cycle, the changes into nympha and adult being effected without dropping off to the ground. Larvae born of mothers which fed on an infected animal are capable of transmitting the parasite, which therefore passes through the egg. The credit of this discovery is due to Smith and Kilborn.

Pathogenesis. This parasite is the cause of Redwater in

cattle, a disease also frequently spoken of under the local name Texas Fever, or Tick Fever. The parasite appears in the blood about a week or ten days after inoculation or infection of a susceptible animal by means of ticks. In multiplying, the red blood corpuscles are destroyed, causing the host to become very anaemic. The mortality is very variable, and in the case of cattle imported from clean land to infected pastures it may be high. On the other hand calves reared on infected pastures less frequently show any marked symptoms, although their blood contains the *Babesia* and is capable of maintaining the infection of ticks. This resistance may be broken down by means of a concomitant disease or when the vitality is much reduced.

Babesia canis. Piana and Galli-Valero.

Hosts. Dog.

Distribution. Europe (France), Asia, and Africa. It has not yet been described from America or Australia. We do not know of any area in East Africa which is free of the parasite.

Morphology. Very similar to *B. bigemina* of cattle. This parasite has been the special study of Nuttall and Graham-Smith, who have described the development within the mammalian host. According to these authors a free pear-shaped body enters a red blood corpuscle and there first becomes rounded and then amoeboid. At this time nuclear changes are taking place which result in a bifid budding of the body. Finally, formation of twin pear-shaped parasites occurs, and the corpuscle is destroyed so as to allow of these forms becoming free and available for the attack of new corpuscles.

Christopher has followed the development within the tick—*Rhipicephalus sanguineus*—which is found to transmit the infection in India, and has traced into the ovaries and salivary glands bodies which he regards as forms of the *Babesia.*

Transmission. Loundsbury and Robertson were the first to prove transmission of *Babesia canis* by means of *Haemaphysalis leachi*—the common dog tick—in South Africa. Infection

is received by the female of one generation and is carried through the egg, larval and nymphal stages to be given to a new animal when it reaches the adult stage. This tick is common in East Africa, and in addition we have here *Rhipicephalus sanguineus*—one of the brown ticks—which Christopher has shown capable of spreading the parasite in India. This author has found that *Rh. sanguineus* may acquire and give infection in a like manner to that described for *Haemaphysalis leachi*—in this case the developmental forms pass to the ovaries—and also that clean nymphae placed on an infected dog will acquire an infection which can be transmitted after the next succeeding moult. In this case developmental forms pass straight to the salivary glands.

In discussing the genus *Babesia* and particularly *B. canis* mention must be made of the drug Trypanblau, which was introduced by Nuttall and Hadwin for the treatment of Tick Fever or Malignant Jaundice in dogs. Experience in Nairobi has demonstrated that when properly administered the action upon the parasite is almost immediate, and the drug may fairly be considered a specific for the disease. It is an interesting fact that Trypanblau has no action on the allied genus *Theileria*, and present observations go to show that it has little or no effect upon the genus *Nuttallia* (*Piroplasma equi*).

Pathogenesis. The pathology of tick fever in the dog is very similar to the disease in cattle due to *B. bigemina*, that is to say there is a breaking down of the red blood corpuscles and resulting anaemia. Further, imported and highly bred dogs are more susceptible than pariahs and those which have been exposed to infection since they were born. The blood of a recovered animal contains the parasite, though they are usually too scanty to be found microscopically, and is infective for ticks and other dogs. Relapses may therefore occur as a sequel to another disease, and not necessarily as a result of a re-infection.

Babesia mutans. Theiler.

Hosts. Cattle. Very similar parasites have been seen in deer in Portugal.

Distribution. General in Africa. Morphologically identical forms have been described from India, Australia, Japan, and Transcaucasia.

Morphology. Occurs usually in the form of delicate rods and rings, the former measuring 1μ to 2μ in length, the latter 1μ to $1{\cdot}5\mu$ in diameter. In appearance they are practically indistinguishable from *Theileria parva,* though a multiple invasion of a single red corpuscle is less common. No bodies resembling Koch's bodies have been seen in connexion with this parasite. Bettencourt has placed this species in the genus *Theileria,* but it appears advisable to limit that generic name to those parasites which are non-inoculable by direct transference of blood.

GENUS, *Nuttallia.* Franca.
SPECIES, *Nuttallia equi.* Laveran.
SYN. *Piroplasma equi.* Laveran, 1901.

Hosts. Horse, mule, donkey, zebra (P. H. Ross, Theiler).

Distribution. Africa, including Madagascar, and India are the territories mainly affected, and it is known to be widely disseminated in East Africa.

Morphology. The parasite is small, varying from 1μ to $2{\cdot}50\mu$ in length and is frequently ovoid in shape. Twin pear-shaped forms comparable to *Babesia bigemina* or *B. canis* do not appear. It is not uncommon to meet with four or more individuals in a single corpuscle arranged as a cross or in a radial manner.

Transmission. Theiler has shown that *Rhipicephalus evertsi* (the common red-legged tick) is the chief transmitting agent. Infection is acquired during the larval or nymphal stages, both of which are passed on one host, and is given by an adult to a second host.

Pathogenesis. In general, Biliary Fever of Horses shows a similar train of symptoms to those of tick fever in cattle and in dogs, viz. fever and anaemia. The disease is readily inoculated by means of blood, and the parasite remains in the system of a recovered or 'salted' equine, and may therefore cause a relapse.

GENUS, *Theileria*. Bettencourt, Franca and Borges.
SPECIES, *Theileria parva*.
SYN. *Piroplasma parvum*. Theiler, 1903.

This genus contains as yet only one species, *T. parva*, the parasite of East Coast Fever, and is peculiar among the intracorpuscular parasites of bovines in being non-inoculable by means of blood. Bettencourt placed the species *B. mutans* in this genus. As this parasite is inoculable in blood, it would appear better to place it elsewhere, although the morphology has not yet been shown to conform to Nuttall's requirements for the genus *Babesia*. The devastation caused by this parasite in South Africa since the year 1902 is well known. In East Africa *T. parva* has been recognised in the Ukamba Province, notably in the Kikuyu and Uakamba countries, and in the Nyanza Province. It is also known to occur in the Seyedie Province, and elsewhere on the coast. The Sleeping Sickness Commission of the Royal Society found it present in Uganda, and it is now believed to have a wide distribution around Lake Victoria.

Morphology. The parasite as it occurs in the red blood corpuscles is usually in the shape of delicate rods rarely exceeding 2μ in length, or rings of 1μ to $1{\cdot}5\mu$ in diameter; oval and ovoid forms also occur. Koch was the first (1897) to notice the occurrence of peculiar forms in the lymphatic glands, spleen, and less numerously in other organs of animals suffering from this disease. These 'Plasma Kugeln,' or 'Koch bodies' as they are now called, are met with either free or as intraleucocytic bodies, varying from 10μ to 14μ in diameter. The cytoplasm stains blue with Romanowsky's modification, and contains within it a variable number of purple staining granules. Two types of this body may be recognised; that in which the granules are coarse and less numerous, and a second in which they are very fine and densely packed in the cytoplasm. In such of the latter forms as are mature and have been broken down in the preparation of the film it will be seen that each red or purple dot is associated with a delicate blue body. The individual picture is that of an extra-cellular *Theileria*. Nuttall, Fantham, and Porter have demonstrated that a multi-

plication of the parasite in the circulation such as occurs in *Babesia* is practically unknown, and, since the percentage of invaded corpuscles at the acme of infection is frequently 90 per cent., it is obvious that a factory must exist somewhere within the body from which the red blood corpuscles become invaded. It is suggested that the red blood corpuscles act merely as mechanical carriers of the parasite, enabling the ticks which are feeding on the peripheral capillaries to acquire infection and so maintain the species, and that this factory is in all probability represented by certain forms of Koch's bodies. The view that Koch's bodies have no connexion with *Theileria* was advanced by Martin Meyer, but has received scanty support. In the opinion of all who have had experience of East Coast Fever, these bodies are diagnostic of the disease, and must be accepted as part of the life cycle of the intracorpuscular form.

Gonder has recently published his observations on Koch's bodies in relation to *Theileria* and has indicated the place held by them in the life cycle.

Transmission. Loundsbury was the first to prove the transmission of East Coast Fever by means of a tick, *Rhipicephalus appendiculatus* (the brown tick). Theiler subsequently substantiated this and further proved that *Rh. simus* (the black-pitted tick), *Rh. capensis*, *Rh. evertsi* (the red-legged tick), and *Rh. nitens* may carry on the development of *Theileria*. The transmission of the parasite is effected by nymphae and by adults which have acquired the infection as larvae and as nymphae respectively. Ticks which make use of at least two hosts, more commonly three, must be viewed with suspicion, and it is possible that *Rh. pulchellus*, so common on the Athi Plains, may also act as a carrier.

A larva or nympha having fed on an infected animal drops off when replete and takes three weeks or more, according to season, to moult. It is only after this change that such a tick becomes capable of giving infection, and this knowledge is of the utmost practical value, since by its scientific application one can save from contact and infection all non-infected animals.

Pathogenesis. East Coast Fever first manifests itself by a rise in temperature between the tenth and twentieth day after

the bite of the infecting tick, and in a fatal case the ox dies ten to eighteen days later. In the course of the disease there is no destruction of the blood corpuscles and no anaemia. In South Africa the mortality is about 95 per cent. of affected animals. In East Africa it is impossible yet to arrive at any exact estimate. In some outbreaks the mortality has closely approximated to the South African figure, whilst in others losses have been small. This is probably largely accounted for by the fact now becoming recognised that this disease is endemic in some parts of this Protectorate. In these areas some or all of the cattle are attacked as calves. Either by virtue of their age, or possibly owing to some inherited influence, a large proportion of these recover and resist infection when subsequently exposed. The experience in South Africa has been that the immunity following recovery from East Coast Fever is absolute, that is to say it cannot be broken down. One observation in German East Africa and one instance in this Protectorate lend colour to a view that the immunity may break down. There is yet, however, no evidence to indicate that the parasite remains in the body after recovery, or that a tick feeding thereon could acquire infection. Another point of distinction from *Babesia bigemina* and *B. canis* is that the parasite cannot be inoculated by means of blood. Recently K. F. Meyer has been able to reproduce infection by the transference of portions of spleen from a recently dead animal into the peritoneal cavity of a susceptible ox, and we have succeeded in corroborating this experiment. It is conceivable that it is necessary for certain forms of Koch's bodies to gain entrance before infection can be established, and since these bodies are only very exceptionally formed in the blood, non-transmission by inoculation of blood corpuscles, even though heavily invaded by *Theileria*, is explained.

GENUS, *Anaplasma*. Theiler, 1910.
SPECIES, *Anaplasma marginale*. Theiler.

The exact zoological position of this parasite is still an open question, and must remain so until more knowledge of its life cycle is obtained. There is, however, small room

for doubt that it will find a place in the order *Haemosporidia.* In anticipation of this it is discussed here.

Hosts. Up to now cattle alone have been found to harbour the parasite.

Distribution. Anaplasma apparently has a wide geographical distribution—America, North and South, Transcaucasia, and it has been detected in all parts of Africa where systematic examinations of blood were made. In East Africa we have noted it principally around Nairobi and Naivasha, possibly as these districts possess a good proportion of grade and pure bred cattle which are more susceptible than native stock. Theiler found it present in slides from Uganda.

Morphology occurs as rounded or ovoid bodies of about 1μ in diameter; no definite structure can be made out by Romanowsky staining, the whole body taking a deep modified chromatine tint. They are most frequently situated at the periphery of the red blood corpuscles—hence the specific name.

Transmission. Theiler has shown that the common blue tick (*Boophilus decoloratus*) can carry the parasite. As is the case with *B. bigemina* and the same tick, the organism passes through the egg of a mother fed upon an infected animal.

Pathogenesis. The early workers on Redwater in cattle—Smith and Kilborn, Lignieres, &c.—noted the occurrence of 'peripheral coccus-like bodies' which were regarded as a form of *B. bigemina* associated with a relapse of the disease.

To Theiler belongs the credit of proving that these parasites are distinct zoological entities. *Anaplasma* is connected with one of the many diseases commonly grouped by the lay mind as 'Gall sickness'; *Babesia mutans* is responsible for another form of this same condition. It can be conveyed by the inoculation of blood taken from a sick animal, and also, as is the case with *Babesia* and *Nuttallia,* with the blood drawn from a recovered animal.