

normal, and in the same condition as the internal thoracic. The lungs, with the exception of an old-standing pleurisy, were normal.

This case differs from the one reported by M. Nocard in that no nodules were found in the lungs. At the time of the *post-mortem* I was in doubt as to what disease the animal had died from, and I was greatly struck with the resemblance between this case and the one reported in the *Record* of 23rd November, which reached me about a fortnight after the death of this animal.

---

## EQUINE MALARIA.<sup>1</sup>

By ARNOLD THEILER, Veterinary Surgeon, Pretoria.

### THE PARASITE OF EQUINE MALARIA.

So far as I was able to ascertain from the literature to which I had access at the time when this investigation was completed, which was about a year and a half ago, malarial fever had not been anywhere certainly recognised as a disease of the horse. On account of the war, I do not know what has since then been published in connection with the subject of malaria. The introduction of foreign horses unaccustomed to this climate has recently provided me with a large amount of material for the study of this disease, and I have thereby been able to verify and complete the results which I had previously obtained.

"It would appear that intermittent fever has also been observed among the domesticated animals, and indeed in a by no means small number of cases." Friedberger and Fröhner (4th Edition) thus begin their article on malaria, and they then proceed to cite the various types of the disease as it occurs in the human subject. According to them, the occurrence of malaria among the domesticated animals must be admitted. This opinion is supported by the alleged successful experimental transmission of this fever from man to the dog and rabbit; but, so far as I can remember, the experiments in question are scarcely free from doubt, for later observers, who have employed the microscope to diagnose malaria with certainty, have not been able to obtain the same results. The view that intermittent fever occurs in the horse is also supported by reports from Italy, according to which quinine has been employed with good results in some cases. But, so far as I know, none of the numerous investigators of malaria in Italy, who have certainly examined the blood of many animals, have as yet reported the occurrence of any disease of the horse caused by protozoa. According to Dupuy, equine malaria occurs in Senegambia. Unfortunately, I have not been able to consult his articles, but I cite them here because they are referred to by Friedberger and Fröhner, and also by Schneidemühl. According to the last of these authors, reports have long been in existence with regard to the occurrence of malaria in the lower animals, and especially in the horse. But, as Schneidemühl himself assumes in the case of the sheep and ox, it is possible that anthrax has in many of these cases been confounded with malaria. Popov (cited by the above authors) observed in the

<sup>1</sup> A thesis presented on graduation as Doctor at the University of Bern.

Caucasus a disease which was curable with quinine, and which prevailed at a time when numerous cases of malaria were also occurring among the human population. It is possible that this was actually malaria, but the strict proof, viz., the recognition of the parasite in the blood, is wanting. This applies also to the statements made by Sanders, who reported that intermittent fever not seldom occurs among the horses and cattle in Africa. Trustworthy views concerning malaria are contained in Pierre's reports on "Paludism in the horse," but, unfortunately, the complete work has not been published, and in the report which Cadiot made to the Société Centrale one misses what is the essential item of proof, viz., an accurate description of the hæmatozoon alleged to be the cause of the fever. On this account Laveran concludes that the disease described by Pierre was perhaps nagana—the affection caused by the tsetse fly. In the article referred to mention is made of crescentic forms, and these I have not yet found in the horse. It is also said that the parasites quickly disappear from the middle of the blood corpuscles unless care is taken to fix the preparations, so that one has no opportunity to study the shape of the parasites. Pierre is also said to have seen sporozoa in the blood corpuscles, and this is more in agreement with my observations. However, by way of difference, there remains the fact that the bodies observed by me in the blood discs are non-motile and recognisable without any fixation. The description which is given of the paludism agrees upon the whole with my observations, but a quite similar set of symptoms and lesions are met with in the disease caused by the trypanosoma. I am therefore probably not wrong in assuming that under the term paludism Pierre has united two different diseases, or perhaps even more.

Friedberger and Fröhner, and also Schneidemühl, adopt the views of Burke, who identifies the Indian disease "surra" with malaria. That, however, is an error, as the parasite of the former disease belongs not to the sporozoa but to the flagellata. Indeed, if the term malaria had to be applied merely as indicating the course of the fever, then surra as well as the South African tsetse disease would approximate more closely to the intermittent fever of man than to the equine malaria which I am here describing. Especially in horses and mules suffering from tsetse disease, there may set in and continue for a long time a periodicity in the variations of temperature such as is hardly ever seen in any other disease except intermittent fever of man.

By malaria one understands at the present day a disease caused by a specific parasite which inhabits the red blood corpuscles. To this class belongs the *Laverania Danilewski*, which, in South Africa, and especially in Pretoria, is present in almost every pigeon, and must occasionally be regarded as the cause of death, since in diseased birds one finds almost all the blood corpuscles to have one or several parasites. To the hæmamœba apparently also belongs the parasite described by Kolle as occurring in the blood of South African cattle. In the same class may be included the parasite of Texas fever, investigated by Smith in America, and, as I was able to convince myself, identical with the South African red water, the Australian tick fever, and the Argentine tristezza; also the parasites of cattle malaria which were found in Italy by Celli and Santori, and by

Nicolle and Adil-bey in Turkey; and those found by Babes in the hæmoglobinuria of Roumanian cattle and sheep. It must be distinctly understood that the parasite which was first described by Kolle as occurring amongst South African cattle has nothing to do with Texas fever, red water, or the cattle malaria of the Italians, but constitutes a special variety.

I am unable to identify the hæmamœba studied by me in connection with equine malaria with any of those previously described. I regard it as a distinct variety, and for the sake of brevity I call it the equine amœba or hæmamœba, or the *plasmodium malariae equorum*. It most closely resembles the parasites found in man, but is not identical with them.

Koch distinguishes four forms of human malaria, viz., tropical malaria, tertiana, quartana, and irregular malaria, because each of these has a special variety of parasite, and because they also differ among themselves clinically. The tropical malaria is identical with the malignant tertiana described by Bignami and Marchiafava, and included by Ziemann under the group of irregular fevers, in which the parasites in the blood assume the crescent form.

Equine malaria ought now to be classified with these, but that is not very easy. Clinically, and taking account of the course of the fever, it may be placed alongside of the irregular pernicious forms of the human disease, but the parasites found in the two conditions are different. We miss especially the crescent forms, which are of special value for the differential diagnosis of this type of human disease.

As already mentioned, the malaria plasmodium of the horse can after a little practice be easily recognised in a stained preparation of blood from an affected animal. However, I prefer for examination the living blood to stained preparations, because in the former the outlines are cleaner and more distinct. The smallest parasites take the form of little points, the largest of which are about from one third to one fifth of the size of a red blood corpuscle; only exceptionally do they appear larger. They present themselves as clear, strongly refractile round discs, standing out prominently against the dark background of the blood corpuscles. Apparently the larger forms fill up the whole thickness of the blood corpuscle, for in their case the background is not darker, but clearer. The normal form is that of a sphere. The edge is quite sharp, and, indeed, now and again one gets the impression that the small discs project in relief about the level of the blood corpuscles. The edge appears to be thickened, as the centre is clearer. However, most of the parasites present a uniform homogeneous or very finely granular surface. In addition to the round forms, other shapes occur, such as oval, pear-shaped, spindle-shaped, and rod-like. The outlines are always distinct, and the bodies are easily recognised as something foreign to the blood corpuscles.

The very small forms are motile. Within the blood corpuscles they show a change of position resembling the Brownian movement. The somewhat larger forms are less actively motile, and the fully developed forms are quite motionless. In the case of the medium-sized parasites one can often observe that they very slowly change their position within the blood corpuscles, approaching sometimes to the one or other edge and sometimes to the centre. I have not been able to

observe the protrusion or protoplasmic processes, although appearances observable in stained preparations suggest the possibility of such a thing. Whether pigment is formed in the parasites could not be made out with certainty. In the largest forms I could sometimes detect moving granules, the nature of which is unknown to me. However, if pigment granules are present, they are very small. I may here mention that on one occasion a minute body which I took to be a parasite escaped from a blood cell and then exhibited active movements. However, it ought to be specially mentioned that I never observed flagellated parasites. As a rule, a blood corpuscle contains only one parasite, but sometimes several (up to four). Very often a small motile body is observable alongside a large one. I have not been able to make out what relationship these two forms bear to each other. Where three or four parasites of the same size are present one may assume that they have resulted from the division of a single individual, and this can be made out distinctly in stained preparations. In living parasites I was never able to detect a nucleus with certainty, the whole parasite appearing to be homogeneous. In structure, colour, and transparency it comes nearest to the pigment-free part of the *Laverania Danilewski*.

The aniline colours used for the protozoa are more or less successful for the staining of these parasites. The quickest method, and one that is quite sufficient for diagnosis, is to stain with Kühne's methylene blue, Löffler's blue, or Nicolle's thionin, modified by Marchoux. I was not able to stain the parasites by Ziemann's method, owing to the absence of the proper staining materials. In most cases I failed to stain by Laveran's method. Occasionally, but not constantly, I obtained good results with simple watery solutions of gentian-violet, fuchsin, etc.

The parasite of equine malaria is decidedly eosinophilous. In double-stained preparations, that is to say, stained first with eosin and then contrast-stained with concentrated methylene blue, only a few of the parasites still show a shimmer of blue within the red blood discs; indeed, in such circumstances fewer are visible than in unstained blood. I succeeded best in double-staining by first staining quickly (two to five seconds) with eosin, and then staining slowly (three to five minutes) with methylene blue. Simultaneous staining with the two colours is not so good. It appears to me that the plasmodium is still more difficult to stain than the Texas fever parasite, the colouring of which is difficult enough. I also observed a difference between staining with methylene blue on the one hand, and with thionin and Laveran's stain on the other, the parasite appearing larger with the former than with the latter. This fact suggests that methylene blue stains the whole parasite, whereas with the other two stains only the central part of it is coloured.

In a well-stained preparation the parasite appears as a circle, or as a closed ring if the centre is pale; or, lastly, as a crescent when only a part of the edge has taken on the stain. Less frequently one observes parasites that are oval, rod-like, or shaped like a willow leaf. In agglomerations of blood corpuscles the parasites appear to be irregularly torn. It is possible that many of these varieties of shape may have been determined by defects in the method of preparation. In many parasites one can make out a marginal or central point of variable

size. Frequently, one finds two bodies of this sort near one another or separated by a short interval in the same disc, and often these are observable only with Laveran's method of staining. On this account the parasites appear smaller, but these points are not always sharply marked off. As in unstained preparations, so also in stained ones, the point in comparison with the blood disc is sometimes very minute, and at others of considerable size. The parasite is also met with in the rosette form, consisting of four pieces of the same size, often lancet-shaped, and appearing to hang together in the centre. The largest rosette forms appear to have greater dimensions than the largest round forms, but possibly this is only an optical illusion, owing to the divisions standing out from one another. The division into four leaves is shown by indentations placed crossways in the round disc of the plasmodium. These indentations become deeper, and the single pieces thus become separated from the parent body. In many cases the whole four pieces lie irregularly disposed beside one another, and here and there one of them has already passed out of the blood corpuscle, so that only two or three daughter structures are left in it. Now and again in one blood corpuscle I have seen five pieces, of which four formed a more or less regular rosette, while the fifth was free from that. This appearance suggested to me that in these cases there might be a central body in which the pigment collects before division, as is the case with the quartan parasite of the human subject. The possibility of a double infection must also be admitted.

The method of development of a parasite would therefore appear to be as follows. A young individual which has escaped from a blood corpuscle seeks out another corpuscle. In virtue of its amœboid movement it sinks into the latter. Its movements become slower and soon cease altogether, there being no further occasion for them. The motionless round discs of largest dimensions represent the parasite before division. Then follows division, and the cycle begins again.

The number of parasites in the blood is variable. In the stage of high fever one may count one parasite for every five or ten blood corpuscles. The rosette forms are present in variable numbers both in the circulating blood and in the spleen. Often they cannot be found at all, or only after long searching. I have gained the impression that the parasites of this form are most numerous in the fatal cases. It has also been my experience that the rosettes are very seldom present when quinine has been freely administered. On one occasion I found them more numerous present in the spleen than the simple round form.

At first the red corpuscles which carry the parasites show no microscopic alteration; rarely they are larger than the others. It is only later, when the anæmia has become very pronounced, that one finds very many proportionally large and pale blood discs. When these have been scattered throughout the field of the microscope, I have now and again noticed that they showed a slight trembling motion; but whether this appearance was ascribable to Brownian molecular movement or to movement of the parasites I was unable to determine. Apparently free parasites must also occur in the blood serum. However, some reserve ought to be observed in regarding these actively moving round discs, which, at the outset one recog-

nises between the red blood corpuscles, as parasites, for similar structures may also be found in quite normal blood. Apparently they are blood plates which have become free. On the other hand, the artificially stained particles attached to the blood discs ought to be regarded as free parasites. It is especially in the spleen that these are found to be numerous present. That such bodies are of a parasitic character follows from the observation that similar forms are not present in normal blood, from the distinctness of the shape of the uncoloured parasites in the blood discs, from the rosette forms, from the constant occurrence of a specific combination of symptoms, and, lastly, from a comparison with the analogous parasite of Texas fever and human malaria.

It might have occurred to one that these bodies are nucleated red blood corpuscles, such as are occasionally found in cases of extreme anæmia (tsetse disease), for the round disc of the parasites is not unlike a vesicular nucleus. However, observations made in cases of tsetse disease show that such nuclei are stained intensely with anilin colours. Comparison with the nuclei of the blood of the fowl shows that our parasite is more refractile than these.

Superficial examination might also lead one to mistake shrunken blood corpuscles in unstained blood for parasites. To distinguish between them the tube of the microscope ought to be alternately lowered and raised, by which procedure shrunken corpuscles gradually appear broader as one focusses in the downward direction, whereas the parasites suddenly appear with their maximum outline in the field of the microscope, and are more strongly refractile than the former.

Lastly, mistakes may also be made in examining stained preparations, but the intense colouration, the irregular disposition, and the absence of rosette forms are sufficient to enable one to distinguish the parasites from all other accidental structures.

As already mentioned, notwithstanding prolonged observation repeated on several successive days, I have not been able to observe flagellated or crescent forms. By way of control I compared my blood specimens with the flagellated *Laverania Danilewski*. As is well known, the crescent forms of the human subject are regarded as sterile parasites, which appear when recovery is about to take place. The same might have been expected in equine malaria, but I was never able to find such bodies. During convalescence the number of parasites simply declined from day to day, so that after the fever had disappeared the parasites could only be found with difficulty. How long the parasite takes in development is unknown. When a case of the disease has been diagnosed one finds that the parasites are present all day and every day, and also the rosette forms under the before-mentioned circumstances.

Compared with the plasmodium of human malaria, the parasite of equine malaria approaches somewhat closely to the ring-shaped parasite of the æstivo autumnal fever of the Italians, that is to say, to the malignant tertiana of Bignami and Koch. There also one finds the small forms of the parasites, of which the motility is pronounced only in their early stage. As a rule these also form pigment, and during division they assume a rosette arrangement. However, there are important differences between the two. The

pronounced ring-shape, such as is found in malignant tertiana, as a rule is not present in equine malaria. In the former division does not take place in the circulating blood, but first occurs in the spleen, and it results in the formation of more numerous pieces than in the latter. Lastly, the crescent forms occur in tertiana, but not in equine malaria. In respect of the method of multiplication, the parasite of equine malaria approaches more nearly to that of quartana of the human subject, in which division also takes place in the circulating blood, while crescents are absent, and motility is most active in the early stage of the parasite. However, the quartana parasite forms pigment, and causes a quite typical fever. Moreover, it is of much larger size than the equine malaria parasite. It is, therefore, impossible to identify this hæmosporidium of the horse with any of those described as occurring in man.

TO INFLUENCE OF LOCALITY AND TIME OF YEAR.  
PREDISPOSITION AND IMMUNITY.

Without doubt equine malaria has existed for a long time in South Africa, and apparently it is identical with what is called "bilious fever" by the veterinary surgeons of Cape Colony and Natal. At first I also regarded it as a disease of the liver, until systematic examination of the blood in the investigation of various South African diseases led me to recognise its true nature. I have met with the disease in Johannesburg and other parts of the Transvaal, chiefly in Pretoria; also in horses from Basutoland and the Orange River Colony, but recently especially in horses imported for the war. I saw it among horses from England, New Zealand, Australia, and the Argentine Republic. Horses from the latter country formed an important contingent among the animals affected with this disease.

Wiltshire, who was at one time veterinary surgeon in Natal, in the *Natal Almanac* for 1883 described the disease as "anthrax fever," and his description agrees with the one given by Hutcheon of "biliary fever." Before the outbreak of the war Verney, in the monthly reports issued by Pitchford, the chief veterinary surgeon in Natal, mentioned the occurrence of biliary fever among horses from South America. This observation, as well as my own, would appear to indicate that Argentine horses are very susceptible to equine malaria.

As a rule the disease attacks only single individuals, but it may appear in the epizootic form, when, as is at present the case, there are large numbers of susceptible horses. The distribution of the virus and the susceptibility of the animals are the principal factors determining the frequency of cases. I have often, and especially of late, seen convincing evidence of this. It would appear that certain telluric and climatic conditions are also necessary for the development of the disease. Hutcheon reports that in Cape Colony cases occasionally occur everywhere and at all seasons of the year, but that as an enzootic disease it prevails only in certain well-defined districts. It appears to be especially enzootic in certain low-lying farms shut in by high hills. It is seldom found in the Cape peninsula, but, on the other hand, often on the east coast, and as far inland as 100 miles.

In the Transvaal I observed it both on the high and on the low

veldt, almost always in summer, especially before the rainy season, but also after that. Hutcheon saw the disease throughout the whole year, but chiefly after the rainy season, and also in the summer and autumn. According to my observations, rain has nothing to do with malarial fever. Up to the present time this year we have had no rainfall worth mentioning, and yet cases of equine malaria have been rather frequent. The way in which horses are kept does not appear to have any great influence on their disposition to contract the disease. I have seen both fat and lean horses attacked by it. Hutcheon also has seen it among racehorses. Horses kept in the stable appear to be less frequently attacked than those grazing in the fields. In the Artillery stables here I observed in the course of two years only a single case, and this particular horse had a short time previously been at grass. Most of the Artillery horses are American, but I have never seen one of them attacked with malaria. On the other hand, I have seen malaria in the stables in Pretoria, and my colleague Scott tells me the same with regard to his experience in Johannesburg. I have never seen the disease enzootic except among horses at grass; and, as already mentioned, it is especially of late that I have observed this, since the English horses could not be accommodated in stables, and had to be camped in the open.

The disease apparently is not at all contagious. All observations indicate this. For example, I have seen many animals in a troop of imported Basuto horses simultaneously attacked when they were exposed to the same conditions, and this although there had not previously been any case to which one could refer the outbreak. Nor have I ever observed that the disease has been carried by affected horses. In the Artillery stables a horse which had been going at grass died from malaria, but this was not followed by an outbreak of the disease. In my private practice I have also seen cases in which only one horse was attacked and died or recovered, without any of its stable companions contracting the disease. The observations made by Hutcheon in Cape Colony are in agreement with my own. This author, however, supposes that a sort of miasma is the cause of the disease, and in every case he recommends disinfection of the stable. I endeavoured to solve this question in the experimental way. With this object I administered to six horses large doses of non-defibrinated blood, taken on different days and from different diseased animals. The blood was taken partly from living animals and partly at the *post-mortem* examination of animals dead of the disease. Both subcutaneous and intravenous inoculation was employed. As doses of from 5 to 20 cc. did not provoke any reaction, larger doses of from 50 to 100 cc. were injected into the jugular vein, but always without any effect. This result is decidedly striking. We know that human malaria can be transmitted by inoculation with the blood when the inoculated person is susceptible to the disease. From the present point of view, the circumstances connected with Texas fever or South African redwater are more analogous, and my own experience has taught me it is only exceptionally that one succeeds in inoculating this disease to the native cattle or calves of the Transvaal, whereas one generally succeeds with imported cattle. The conditions may be the same in equine malaria. The whole six horses which I inoculated were South African animals, and their



ages varied from four and a half to fifteen years. They were therefore immune against this disease, just as Transvaal cattle are against Texas fever. Still another circumstance speaks in favour of this view—viz., that almost without exception it is among imported horses that one observes equine malaria. We have, however, no proof that horses which resist an attempt to infect them experimentally may not contract the disease in the natural way. It would be difficult to solve this question unless infection took place accidentally. The natural origin of the disease can meanwhile only be inferred from analogies with similar affections and from zoological observations. Texas fever is undoubtedly transmitted by ticks, and the tsetse disease is likewise transmitted by the tsetse fly. The sting of blood-sucking insects induces horse-sickness, and the sting of a mosquito is necessary for the production of the proteosoma disease of the fowl as well as for the malaria of the human subject. It is certain that equine malaria has a similar origin.

It may here be observed that the negative result of my attempts to transmit the disease experimentally might be explained by supposing that the parasite has to pass through a phase of development outside the body of the horse, in the insect, before it is able to infect a fresh animal, as is the case in Texas fever and in the proteosoma of the fowl. The time at my disposal has not hitherto permitted me to attempt to solve this question.

Up to the present time I have observed malaria only among horses, but I do not conclude that it does not also attack the ass and the mule. I have not been able to infect other animals, such as monkeys, rabbits, guinea-pigs, mice, and pigeons. It therefore appears that the horse, like man, has his own special malaria parasite.

According to my observations, there are severe and slight cases of malaria. The latter may recover without treatment, and, indeed, may escape observation. The majority of the severe cases are incurable, unless energetic treatment is begun early. All the severe cases which I left untreated in order to study the parasite and its method of development ended fatally, whereas the slight cases, which I left untreated for the same reason, recovered. It ought here to be added that the milder cases can only be detected by microscopic examination of the blood. As soon as the clinical picture of malaria has become fully developed the condition must be regarded as very grave. On this point Hutcheon's experience is in agreement with my own. He finds that most cases of "biliary fever" can be cured when the animals are professionally treated and well looked after.

I take the period of incubation of malaria to be three weeks, and I base this opinion on the following observations. In a troop of healthy recently imported Basuto horses suddenly exposed to infection the disease broke out under my own eyes after twenty-one days.

I am not able to say whether a horse that has recovered from the disease is immune against a new infection. However, I have never known a horse to have two attacks of malaria. It is a well-attested fact that many of our animals have an inherited immunity, a fact analogous to what is observed in Texas fever and human malaria.

## SYMPTOMS.

As regards the course of the disease, one can distinguish an acute and a chronic malaria ; and, as regards the prognosis, a mild and a malignant fever. However, the latter is not recognisable as such from the outset. An acute form of malaria sets in suddenly, and either ends in death or passes into a slow period of convalescence. The fever may disappear at a comparatively early stage, and yet the disease may assume a serious character in consequence of the injurious effects caused by the parasites. After an apparent recovery a relapse may take place, and the original acute symptoms recur with more or less severity. I have also observed a second relapse, though that very seldom occurs. When it does, the disease takes on a chronic course of a somewhat intermittent character ; but, as already mentioned, this has no resemblance to the intermittent fever of man. In consequence of the fact that the temperatures of all the horses in our stables were regularly taken, and the blood always examined as soon as the fever was observed, I was able to study malaria in animals of whose temperature I had a record before they took the disease. In this way I ascertained that the fever may either develop slowly (like the steps of a stair), as in horse sickness, or it may in a brief period reach a considerable height, and then have an irregularly remittent course. In the former case the disease cannot be recognised clinically, but it can be diagnosed by recognition of the hæmatozoa in the blood. At this period the affected horse shows only indefinite signs of being out of sorts. The higher the fever afterwards reaches, or, if it has set in gradually, the longer it lasts, the more distinct becomes the picture of typical malaria ; that is to say, a general icterus which is recognisable by the yellow colour of the visible mucous membranes, and especially of the sclerotic coat of the eye. In no other disease have I in the early stage seen such a pure, light, amber-yellow colour of the tissues. This is more or less intense, and its intensity may be taken as a measure of the gravity of the disease. In mild cases, justifying a favourable prognosis, the yellow colour is distinct, but not so pronounced. Even at some distance the yellow discolouration is observable in all the visible mucous membranes—nose, mouth, anus, and sheath ; the pigment-free parts of the skin also become distinctly yellow. If recovery sets in the yellow colour disappears only slowly. The fever may long have disappeared, and the horse have acquired the best of appetites, while the still present jaundice indicates that he has recently passed through an attack of the disease. When the horse recovers, the yellow colouration may be confined to the eyes. In severe cases, and especially in those that end fatally, spots of extravasation may appear on the mucous membranes. At the outset, only a few of these are present, but later on they are so numerous that the mucous membrane appears dotted all over with them. The colour of these spots is not at all a pure blood-red, but a reddish-brown. When they become confluent there develops a uniform dirty reddish-brown discolouration, which may be taken as a measure of the gravity of the attack. Hitherto I have seen these uniform discolourations only on the conjunctivæ. The eyes take on a tired, sleepy expression, are half closed, and tears often flow from between the eyelids. The animal hangs its head and

stands in such a way as to suggest general exhaustion. This is also further shown by a staggering uncertain gait, by frequent lying down, and appearance of stupor.

Occasionally the fight for life extends over several days. The symptoms exhibited generally recall those of chronic hydrocephalus. The legs are kept in abnormal positions, and the animal leans against the wall, stands across the stall, or hangs on the halter. When loosed the horse sways from side to side or stumbles forwards, wanders around seeking out localities that it formerly shunned, and towards the end it is found down in a hole dug out by its own death struggles. This combination of symptoms is especially distinct in the chronic type of the disease, and when the fever disappears some time before death.

In very acute cases death may occur when the fever is at its height. In such a case the symptoms become very urgent and end in collapse; the heart's action especially is very excited. The pulse becomes quick, weak, and eventually imperceptible. The respirations take on an abdominal character and become increased in frequency. The temperature sinks below the normal; the horse lies down, trembles, becomes comatose, refuses to eat, supports his head on the ground, and dies in from six to twelve hours.

In all the comparatively severe cases the heart's action is much disturbed. Even in cases that end in recovery the arterial pulse may be very small, while there is a strong pulse in the veins. There is a shortness of breath, which, however, is not attributable to any alterations in the lung tissue.

Frequent and even violent respiratory movements of an abdominal character are apparently the result of interference with the heart's action and with the aeration of the blood.

From the very beginning the appetite is diminished, and it is soon lost altogether. I have seen horses which for a whole week refused to eat even the best of food; at the same time the thirst was increased. Constipation is often present at the outset, and it may continue during the whole course of the disease, or it may be replaced by a diarrhoea in which foul-smelling yellow faeces are passed. Constipation and diarrhoea often alternate with one another.

In severe cases the urine is altered even at a very early stage of the disease. It becomes darker in colour, and it may be so laden with colouring matter that it will stain white horse hairs or white cloth moistened with it an intense yellow. When there is a pronounced general jaundice polyuria generally sets in, and the excretion of urine is most copious in animals that are recovering. By this symptom alone I have been able to detect mild attacks of malaria.

General emaciation quickly sets in, and the disappearance of fat may be very rapid. Swelling of the legs may also be observed. In horses suffering from malaria, as in the tsetse disease, there is a marked vulnerability of the tissues, owing to which wounds do not heal, but take on an unhealthy appearance and often discharge a quantity of liquid. In one case a subcutaneous injection of spirits of camphor was followed by a local necrosis, and the formation of an enormous inflammatory swelling in the neck, respiration and deglutition being at the same time interfered with; these effects could not be ascribed

to any accidental infection. The condition was such that tracheotomy had to be performed. Many animals exhale a disagreeable odour, especially when marasmus has set in and the end is approaching.

### III. DIAGNOSIS.

Very mild attacks of malaria may simply have the character of a transient fever, and then it is only by microscopic examination that the nature of the disease can be detected. The rosette forms may be found in the blood both in mild and severe cases; and the parasites may quite suddenly disappear although the disease continues. Indeed, there are cases of fully developed malaria, with disturbance of the pulse and temperature, in which one is not able to detect the parasites in the blood at any time. This is easily explainable. The typical infection of the blood has come to an end, but apparently the juices of the body have in large measure lost their natural bactericidal properties, and in such a condition a secondary bacterial invasion from the intestines may take place. By the method of culture the presence of bacteria can then be demonstrated in blood taken from the jugular.

### COURSE.

In acute cases the duration of the disease varies. It very often happens that when one is called in to a dying animal the owner reports that nothing was noticed to be amiss with it on the preceding day. It is quite certain that some cases run an extremely acute course, although this is the exception. I saw several cases in which the duration of the disease was from two to five days. In another acute case which was under observation during the whole of the time the fever lasted for nine days, but the urgent symptoms set in only during the last two days. It is therefore reasonable to conclude that pretty frequently the first stage of the disease is overlooked. Chronic cases may terminate fatally after two to four weeks, and the rule is that any delay in the development of the symptoms must be regarded as an unfavourable sign.

### PROGNOSIS.

The most reliable criteria for diagnosis are found in the quality and frequency of the pulse, and, above all, in the condition of the conjunctiva. According to my experience, it is of little importance whether one can recognise the parasite or not. Its presence in the blood corpuscles indicates that the case is still in an early stage, and when it is absent one may conclude that the malaria proper has passed over into a condition of general jaundice. In both cases the ultimate result will depend upon the strength of the heart. It would be an error to count upon a favourable termination because at the outset the symptoms are of a mild character. Cases which appear to be of the mildest type may terminate in death; and, on the other hand, animals that appear to be very severely attacked may suddenly recover. Hence, the more chronic the course of the disease the less favourable is the prognosis.

## PATHOLOGICAL ANATOMY.

In the less acute cases of the disease, at the *post-mortem* examination one finds the carcase emaciated, and when the skin has been removed there is observed a general discolouration of the white tissues. The muscles have a reddish-brown colour, or at places they may be almost straw-yellow. The body is markedly anæmic, but the indications of poverty of the blood are masked by the jaundice. The spleen is prominent on account of its enormous size, and its capsule is tense. It may weigh as much as 10 lbs. The pulp, which is blackish-brown in colour, swells up when the organ is incised, and under the slightest pressure it flows out as a pultaceous material. When the swelling of the spleen is not so great its consistence is firmer.

When the liver is incised its lobules, which project somewhat on the cut surface, are seen to be yellow, and frequently surrounded by a greenish edge. To these appearances may be added the alterations of chronic venus congestion. The bile ducts contain a large quantity of bile. I always found the orifice of the bile duct patent, and the duodenum always contained bile. The amount of blood in the organ is very variable, but it is always abundant. The kidneys are always enlarged and anæmic, and their texture is saturated with a serous liquid. The fat around the kidneys may be similarly infiltrated. In other cases the only abnormality in the kidneys is anæmia.

As a rule, the lymphatic glands of the spleen, liver, and kidneys are much enlarged and beset with hæmorrhages. Their consistence is very soft. The mesenteric and lumbar glands show no alteration except œdema.

The stomach and intestines are generally shrunken and empty, and they always show the alterations indicative of gastro-intestinal catarrh, often of recent origin. This condition is characterised by the presence of spots, streaks, and points of redness scattered over a larger or smaller extent of the mucous membrane, which is often distinctly thickened; while a tough, viscous, yellowish mucus is adherent to its folds. In other cases the entire mucous membrane shows a slaty discolouration, which might be compared to the skin of an eel.

The bladder is almost always filled with thin reddish-brown urine, and petechiæ may be present on its mucous membrane.

The pleura is also icteric. The pleural sacs do not contain any fluid.

The lungs are everywhere spongy, and their apices are not rarely emphysematous. In only one case did I find infarcts and areas of pneumonia; these, however, were probably the lesions of an aspiration pneumonia. The lymphatic glands at the root of the lung, and to a still greater extent those of the mediastinum, are swollen, gelatinous, and watery.

The heart may be the seat of extensive lesions. Generally the pericardium is normal. In one case I found pericarditis, the surface of the membrane being covered with a yellow, almost dry layer resembling dried ox bile. The vessels of the pericardium were also injected, but only the over-lying pleura was beset with small hæmorrhages. The pericardial fluid may be increased in quantity. Both sides of the heart are much distended with blood. Points and spots of hæmorrhage are present under the endocardium, and there may also

be gelatinous deposits in the same position. In the most severe cases one may find blood extravasation over the whole surface of the heart under the epicardium, accompanied by gelatinous swelling of the root of the aorta and of the cardiac furrows. The muscular tissue of the heart is friable, and it has a cooked appearance.

After death the blood quickly coagulates. Large colourless masses of clot are formed, and the coagulated blood is soft and gelatinous. The serum expressed has a brownish-yellow colour, and it frequently contains blood corpuscles, which subsequently collect at the lowest point and adhere to one another. This appearance is very characteristic, and, as already mentioned, I have observed it even in samples of blood taken during life. I have not observed the same in any other disease.

When death occurred at an early stage of the disease I was always able to find the parasites in the dead body, but never when the course of the disease had been chronic, although the clinical picture had been the same in both cases. I found the hæmatozoa in the blood of the spleen, liver, kidneys, and heart muscle, but most frequently in the spleen, in which also the rosette forms were most numerous present.

#### DIFFERENTIAL DIAGNOSIS.

When equine malaria presents itself at the stage of high fever its recognition is easy and certain. I have never seen such a pronounced condition of jaundice in any other disease, not even in tsetse disease or horse-sickness. The icteric discolouration seen in the course of equine pneumonia and influenza is not a light yellow, but an orange yellow. In malaria the discolouration is a distinct amber-yellow. One should always resort to microscopic examination of the blood in cases of jaundice occurring among horses here, for in most of such cases the parasite of equine malaria can be detected in it. Another point valuable for diagnosis is that when a sample of blood is drawn off from a vein it immediately separates into a stratum of buffy coat and a red clot. The former is relatively thick, amber-yellow, and always more intensely yellow than in a healthy animal. This appearance is of even greater value for diagnosis than the detection of the parasite. Malaria is often confounded with horse-sickness, especially when the latter prevails as an epizootic, but the differential diagnosis cannot present any difficulty to the professional man.

Just as the fully developed clinical picture of malaria cannot be confounded with that of any other disease, so also the lesions of the disease are unmistakable. It is important to be able to demonstrate the presence of the parasites with the microscope. In South Africa there are other diseases, as yet undescribed, which are associated with swelling of the spleen, inflammation of the lymphatic glands, and slight jaundice. Hence, unless one is able to demonstrate the parasites, now and again one may find that the alterations discovered at the *post-mortem* examination are not sufficient to justify a positive diagnosis. However, the striking jaundice and the typical alterations in the blood are characteristic. Anthrax can always be excluded with certainty.

The whole series of pathological alterations corresponds to a type which we also find in other etiologically related diseases of man or

the lower animals. For example, swelling of the spleen is met with in human malaria, in Texas fever, in the malaria-like disease of South African cattle described by Kolle, etc. In these affections also the symptoms of jaundice and of hepatic disturbance are also more or less distinctly present. It will thus be seen that the near relationship of these different diseases is also indicated when one compares the pathological alterations associated with them.

#### INFECTION.

The indispensable condition for the infection of an animal with this disease is that the causal parasite shall find entrance to its system. It is this which determines the typical alterations in the blood, the jaundice, and the liver lesions. The removal of the pathologically altered blood corpuscles is taken up by the liver, spleen, and kidneys. It often happens that the disturbance of health continues long after the parasites have disappeared, apparently because the injured tissues are unable to discharge their normal functions. The inflammatory changes recognisable in all the lymphatic glands point to the presence in the lymph of some highly irritating metabolic product of the parasites, which is responsible for all the before-described lesions.

#### TREATMENT.

The treatment must depend largely on whether the parasites are still present or not. In the former case there is no doubt that with the administration of quinine the number of parasites in the blood diminishes, and that they may be made to disappear entirely by a systematic course of that medicine. That, however, does not suffice to cure the disease, but only to combat its primary cause. At the outset of the disease, when the temperature is still febrile and the parasites are still present, the administration of quinine is indicated. It is advantageous to give several small doses daily, as, for example, six to ten grammes thrice daily. As we have already seen, there are from the outset indications of the necessity for strengthening the heart. For that purpose alcohol is specially valuable, and good results may be obtained with it. When once the fever has disappeared there is no further use for the administration of quinine, the parasites being no longer present. Treatment must be directed to combating the heart weakness. The outflow of bile from the liver must also be stimulated as much as possible, for which purpose small doses of calomel and the ordinary laxatives prove useful. When the bowels are open arsenic may later on be given with very good effects. I prefer to give it in the fluid form. At the same time the animal should be well looked after, as the appetite is often very capricious. I have no information to show whether arsenic has any prophylactic value. Among horse-keepers it is a widely disseminated custom to administer white arsenic to horses with their food, in order to protect them against many different diseases.

---