INTRODUCTION

The host specificity, characteristic of almost all the different parasites is a result of the extreme specialization consequent to the adaptation of parasites to its hosts and host to its parasite during the evolution of the mode of the parasitic behaviour. The adaptation of the parasite to the host naturally involves the ability of the parasite to derive its nutrients from the host in order to thrive and to reproduce. The host in this instance plays a very important role in as much as it has to supply not only the usual nutrients needed by all cells but also to cater to any eccentric requirements of any individual parasite. Such association between the host and the parasite may in the course of time lead to great specificity because of the possible gene mutation of the parasite leading to the development of a highly specific requirement of an metabolite which the host may be able to supply. Such a gene mutation may be substrate induced but it is more probable that it would be random and the ability of the host to supply the mutated requirement may determine the continuance of the host parasite relationship.

Plasmodium, commonly known as a malaria parasite, is a wellknown haemosporidia. The importance of this parasite due to its ability to cause malaria has been well recognised from

the olden days and has prompted many scientific researches both on its biology and on its chemotherapy. Different types of malaria parasites infect different species of animals. Like many other parasitic animals a particular species of Plasmodium shows specificity for a particular host. Various aspects of this host parasite relationship had been investigated by a number of authors. They are :

i) Nutritional basis of host specificity

ii) Specificity in the entry of a parasite into the host cell

iii) Immunological mechanism in the host specificity of a parasite

iv) The importance of zoonosis in host parasite relationship

Nutritional basis of host specificity

A given plasmodium can inhabit and multiply only in the blood of the susceptible host implies that it can not manufacture all of its life materials and depends on the hosts' ability to provide them. The metabolic requirements of the parasites have, therefore, been studied by a number of workers. Most of these studies involved in vitro cultures of the parasite. Since the plasmodia are intra-erythrocytic parasites, the earlier attempts to culture the parasites involved the use of different types of extracts of the erythrocytes and synthetic compounds which were thought essential for culturing a living cell. In 1912 Bass and

Jhons reported a method for the cultivation of two species of human malaria parasites. Proper developments of different intra-erythrocytic stages of malaria parasite in red cell suspensions incubated in vitro was first obtained with two species of the parasite, the bird malaria P. lophurae (Trager, 1941, 1943, 1947) and the monkey malaria, P. knowlesi (Geiman et al., 1946). P. gallinaceum can be cultivated for ten days with chicken erythrocyte extract in the medium (Anderson, 1953). The intra-erythrocytic cultures of different species of malaria parasites were carried out by a number of workers, such as, P. hexamerium (Nydegger and Manwell, 1962), P. falciparum (Geiman, 1948; Trager, 1958, 1966), P. coatney (Trager, 1966).

In all the above instances, the parasites did not grow in the culture medium but were actually found to reside within the erythrocytes. No malaria parasite has as yet been cultured in a non-living medium of even the most complex composition. A sterile stock solution containing balanced salt solutions was prepared for culturing the free parasite (Trager, 1957, 1958, 1964, 1966). Good survival of free parasites at 40°C for one day was observed when the red cell extract was made in medium with gelatin and was supplemented with glutathione nicotinamide at high concentration, and some of the co-factors of glycolysis. The next striking improvement was the addition of ATP and pyruvate which permitted maintenance of most of the parasites for two days (the medium being changed at 18 and 30 hours). The further addition of malate and especially coenzyme A supported the parasites for three days and with folinic acid for 4 days. Inclusion of the lactalbumin hydrolyzate has

improved the survival upto 6th day, a non-dialyzable factor other than hemoglobin was found to support the survival of the parasites (Clarke, 1952; Trager, 1957).

Some of these requirements are more or less needed for almost all cells in general, but there may be some specific requirements in a critical concentration which may determine the ability of a particular parasite to colonize a particular host, since presumably the latter can supply that particular nutrient. Bennett and Trager (1967) showed that P. lophurae lacked the enzyme pantothenate kinase, but the duck erythrocytes had it. Moulder (1962) had earlier shown that Co A was essential for the growth of the parasites. Brewer and Powell (1965) pointed out that P. falciparum developed faster in individuals whose red cells had a relatively higher ATP content.

Many workers carried out experiments in the sphere of the relationship of host-parasite specificity from nutritional and metabolic points of view. McGhee (1950) reported that certain mammalian erythrocytes became infected when introduced into the circulating blood of the chick embryo infected with malaria parasite. These erythrocytes were alike in certain chemical details, as sodium-potassium ratio, concentrations of organic acid soluble phosphate. The infected plasma potassium values were higher than normal, particularly during segmentation (McKee et al., 1946). Recently it has been shown by Sherman and Tanighosi (1971) that sodium concentration of red blood cells rose during the infection

of P. lophurae in white peking ducklings along with a rise of plasma potassium level.

Experiments on host's milk diet also casts some light on the parasite nutrition. Parasitemia was suppressed in the host, kept on milk diet only (Maegraith et al., 1952; Bray and Garnham, 1953). When PABA was added to the host's milk diet, the parasites were seen to develop within the red cells (Hawking, 1953). Anfinsen et al. (1946) stated that some malaria parasite requires this chemical for satisfactory growth in vitro. Later on Vray (1970) again showed the influence of milk diet on P. berghei (Vincke) susceptible or resistant to pyrimethamine, in the white mouse. Meat diet is also deficient in PABA. When PABA was added to meat diet, the mice were infected. (,).

Bastianelli (1959) showed in monkey malaria that the ascorbic acid content of the host promoted growth and metabolism of the parasite.

Host's blood sugar level is also an important factor for the growth of the parasite. MacDougall (1927) observed P. cathemerium infection in hyperglycemic canaries. But Tolbert and McGhee (1960) found P. berghei infection was suppressed in rats with alloxan diabetes.

Allison and Clyde (1961) showed that parasitemia tended to be lower in P. falciparum malaria when the red cells were deficient in glucose-6-phosphate dehydrogenase.

In P. knowlesi infected monkeys, small but consistent increase in erythrocyte GSH (reduced glutathione) were found when the parasites were at ring stage (Fletcher and Maegraith, 1970). Angus et al.,(1971) showed serum lipid altered in monkey when infected with P. knowlesi. Geiman (1964) while reviewing the nutritional basis of host parasite relationship noted, that some protozoan disease unexpectedly become depressed instead of exacerbated, in conditions of famine, presumably because the parasite as well as the hosts were suffering from a lack of nutriment.

Utilization of the host red cell hemoglobin by the parasite, as a chief nutritive material, is generally accepted. Brown (1911) postulated that the splitting of heam from globin was the function of the enzymes possessed by the malaria parasite. Moulder (1962) also stated that the malaria parasites consume host hemoglobin by separating the globin from the heam. The heam was retained as a pigment, hemozoin, inside the cell. Deegan and Maegraith (1956) carried out studies on the nature of malarial pigments of P. knowlesi and P. cynomolgi and showed that the pigment was actually a compound of hematin and a nitrogenous moiety. Sherman and Hall (1960a) stated that the pigment produced by the avian malaria parasite, P. lophurae was protein porphyrin complex. Later on Sherman et al.,(1968) showed that the hemozoin pigment was a hematin-protein complex distinctly different from hemoglobin and hematin and was a heterogenous array of partially degraded hemoglobin molecules.

The parasites were observed to incorporate a portion of the host cell by phagotropy as described by many authors in

different species of Plasmodium, such as P. lophurae (Rudzinska and Trager, 1957), P. berghei (Rudzinska and Trager, 1959), P. gonderi and P. falciparum (Rudzinska et al., 1960), P. knowlesi (Fletcher and Maegraith, 1962) and P. gallinaceum (Ristic and Kreier, 1964). The electron microscopic studies of hemoglobin uptake and its metabolism strengthened the views regarding the degradative origin of hemozoin from hemoglobin. The mechanism involved in the digestion of the content of the food vacuole was more or less as natural pinocytosis elsewhere (Rudzinska et al., 1965). The matrix of the food vacuole became less dense and pigment granules accumulated progressively as digestion proceeded. Newly formed food vacuoles had the same density as the cytoplasm of the host cell.

The type of hemoglobin that can be utilized by a particular malaria parasite was also a factor, determining the ability of the parasite to thrive inside the erythrocyte. Persons homozygous or heterozygous for the gene of sickle cell anaemia were found to be more resistant to falciparum malaria. Moulder (1962) and Motlusky (1964) thought that the parasite had hard time ingesting the hemoglobin S, because of its light viscosity when oxygenated. It was also suggested that the insolubility of the hemoglobin due to the substitution of valine by glutamic acid in sickle cell anaemia had something to do with the resistance of the hemoglobin S erythrocytes to malarial infection (Ingram, 1959). Similar is the case with the fetal hemoglobin, which is insoluble in acid medium and such hosts are resistant to infection for the first three months of life (Allison, 1957).

Hence, it is quite possible that the susceptibility or resistance of species other than man to human malarial infection may be at least in part determined by differences in their hemoglobin structures (Manwell, 1963). Greenberg and Kendrick (1959) showed that hemoglobin is a factor which can produce marked differences in susceptibility of different strains of mice to P. berghei. Inbred strains of mice showed characteristic multiple hemoglobin components, which differed in solubility as well as electrophoretic mobility (Rosa et al., 1958; Popp and Cosgrove, 1959). Preliminary observations showed that strains Streak (which is highly resistant to P. berghei) and Swiss (which is highly susceptible) have hemoglobin types different from one another and from other strains of intermediate susceptibility (Allison, 1963). Recently it was shown that infectivity of P. falciparum, varied in different groups of human population in Vietnam along with the variation of hemoglobin (Bowman et al., 1971).

Specificity in the entry of a parasite into the host cell

As the portal of entry, the host cell surface might be specific for a particular parasite. This surface specificity is very significant in the host parasite relationship in virus. McGhee (1953b), to remove the surface receptor, incubated red cells with cholera vibrio filtrate and also treated the cells with steapsin and carbon monoxide. He then introduced these cells into the embryonic chick, infected with P. lophurae. He was unable to infect the

mammalian erythrocyte with P. lophurae. Shermann (1966) showed that penetration was unaffected by pretreating receptor cells with trypsin, chymotrypsin and neuraminidase and concluded that the malaria parasite lack receptor sites similar to those established for viruses.

Actual entry of a merozoite into a red cell was observed by Trager (1959). The phenomenon of penetration of merozoites of malaria parasites into host cells had been recorded by phase contrast microscopic study (Huff et al., 1960). Weathersby (1966) had shown the entry of exoerythrocytic merozoites of P. gallinaceum into erythrocytes within brain capillaries. Trager (1960) while reviewing on intracellular parasitism and symbiosis stated that the erythrocytes did not appear to have phagocytic activity especially with regard to the erythrocytic stages of the plasmodia. The interaction between malarial merozoites and the erythrocyte surface may be at first a physical one, followed then by enzymatic activity (and perhaps also mechanical activity) on the part of the parasite. Norby and Lyeke (1967) presented evidence for the existence of special proteolytic enzymes in Toxoplasma which enhanced the penetration of the parasite within the erythrocyte. Accordingly a mechanical force may not play a part in the entry or exit of a merozoite, but there must be some specific proteolytic enzyme, secreted by the parasite to dissolve the erythrocyte membrane (Zuckerman, 1968).

The erythrocytic forms have frequently been described by electron microscopy as having two plasma membranes when coming in contact with the host cell cytoplasm (Rudzinska and Trager, 1968). Aikawa (1966) observed the fine structure of merozoites, having a conoid structure, one paired organelles along with other organelles. The conoid is a cone shaped structure, located anteriorly and may possibly function as a perforator when the merozoite invades a host cell. The paired organelles are two osmophilic structures, tear drop shaped, located near the conoid which may secrete proteolytic enzymes through the conoid (Garnham et al., 1960; Ludvik, 1961). Ladda et al. (1969) stated that the malaria parasite did not cause any rupture of the erythrocytic membrane but, there was some orientation and actual penetrance of the merozoites. At the point of contact between the anterior pole of the merozoite and the host cell a focal depression of the red cell membrane formed probably this depression deepened as the merozoites advanced.

So, the question still remains unsettled about the specificity of the surface attachment and the presence of the enzymes, causing the penetrance of the merozoites into the susceptible erythrocytes.

Immunological mechanism in the host specificity of a parasite

During the evolutionary history of association between species, a host manifests either susceptibility or, resistance to a particular kind of parasite based on certain cell to cell

interaction. Since our specific problem is parasitism with the malaria parasites we will consider specifically such adaptive mechanisms of the erythrocytes, or, other special cells for the plasmo-dial forms. The process of entry of the parasite or the so called invasion of the erythrocyte by the parasite may evoke immunological mechanisms, since the plasmodial membrane must have properties different from the erythrocyte membrane. The fortunate fact that the parasites are intracellular renders the association less immunogenic than would otherwise be expected.

Jeffery (1961) showed that P. vivax and P. falciparum being the natural parasites of man could not produce infection in rhesus monkey by inoculation from a heavily infected natural host. The sample that was inoculated by Jeffery to the rhesus monkey contained fifty two million parasite followed by another inoculation after seven days containing eighty million parasites. Inoculation of P. vivax to chimpanzees and P. berghei to insectivorus bats did not develop observable infection and no multiplication of the parasites took place, while subinoculations of blood from these animals to susceptible man and bats could lead to infection in a few months and a few days respectively. The chimpanzee displayed a natural resistance to the erythrocytic forms of P. ovale. The tissue phase of P. ovale was able to grow and reproduce normally in chimpanzee liver and persisted there for at least thirty nine days. The natural resistance of the chimpanzee to the erythrocytic phase was without effect upon the tissue phase of P. ovale (Bray, 1957). Garnham (1963) showed

that in the cebus monkeys, P. cynomolgi, a natural parasite of simian monkeys developed in the liver only upto the preerythrocytic stages but failed to develop in the blood. The canary was naturally immune to both erythrocytic and preerythrocytic stages of P. gallinaceum, a natural parasite of the chicken (Huff and Coulston, 1946). Huff (1957) demonstrated that the sporozoites of a few malaria parasites are able to develop into cryptozoites in various abnormal hosts, but they were unable to infect the erythrocytes or produce gametocyte.

When the sporozoites of P. berghei were inoculated into white mice, infection failed to develop due to the inhibition of preerythrocytic schizogony. On the other hand, when erythrocytic forms were inoculated, the white mice died from overwhelming infections (Vincke, 1954). Such cases of failure to develop infection in abnormal hosts were also observed, like man in the case of P. knowlesi and in abnormal birds to Haemamoeba gallinacea where tissue phases do not develop but blood stages developed to a high degree (Garnham and Lainson, 1957; Coradetti, 1955).

Susceptibility of the vertebrate hosts to a parasite decreases with age. In the case of the malaria parasites, H. gallinacea and H. lophurae could infect the young and the embryonic stage of the chick, but the parasites could not develop in the adult. P. berghei similarly could infect successfully the suckling rabbits but not the adults.

One of the techniques of studying natural immunity to a parasite involves extirpation of organs, taking part in immunological responses. Thus Bray (1957, 1958) showed that splenectomy in chimpanzees, resulted in a total susceptibility of the host to P. falciparum, P. vivax and P. ovale of man. Corradetti (1955) also showed splenectomy produced a diminution of the power of defence of the host and resulted in a lower degree of immunity. Box and Gingrich (1958) showed splenectomy altered immunity to a challenged infection so that a majority of the challenged animals died. Barker et al.,(1971) beside splenectomy used antilymphocyte serum and hydrocortisone as immuno-suppressive agent in rats for P. berghei yoelii. McGhee (1950) studied the susceptibility of naturally immune animals to an infection. With P. lophurae he could infect a number of species, which were thought nonsusceptible to the parasite. Fire back pheasant was chosen as the primary host whose infected blood was injected to duck and then from duck to chick embryo. From the chick embryo, the same was transmitted to baby mice several times repeatedly. It was observed that after each such occasion of transfer, more numbers of rodent corpuscles were invaded with avian blood parasites. Finally, a stage was attained when this transfer could easily be made from baby mice to bay mice directly. Later on, McGhee (1951) reported that the parasites developed in older mice too. The same author later on made a detailed study of the development of the parasites in time. He continued his experiments for three long years and noted that the average intensity of parasitemia increased steadily for several months till it reached a peak and then attained a pleteau

of steady state for the rest period with minor variations. Gametocytes first appeared during the ninth month after inoculation. McGhee also compared his study of mice with that of chick embryo under similar experimental conditions after three years. He found that the sojurn in mice had temporarily disturbed the mean number of merozoites thus produced. Garnham (1963) casually narrated that although the avian blood parasites eventually became adapted to mammalian host their ability to produce gametocyte was lost with the passage of time.

Evidence suggests that the natives of malarious countries who have been exposed to repeated infections with malaria parasite develops a high resistance to malaria and are troubled much less by it than white or, other immigrants. American negroes suffered only a mild disease when they were infected by P. vivax (Allison, 1963). Fairly (1945) stated that a host may exhibit a marked degree of immunity to a parasite as a result of concomittant presence of another infection. This was observed over the subjects who were infected by both P. vivax and P. falciparum. It was observed that the latter infection become dominant in this case and suppressed the former. The host remained temporarily immune to P. vivax. Cox (1968) reported immunity to malaria after recovery from Piroplasmosis in mice. This seems to be a good example of cross immunity. This view of cross immunity was later on confirmed by Cox and Turner (1970).

Box and Gingrich (1958) showed immunity to reinoculation in mice with P. berghei after they had been eradicated by the use

of a curative drug. This immunity was manifested by survival of the majority of animals when challenged with a second infection after cure, where as mortality of mice with an untreated primary infection was always 100%. Barker and Kendall (1971) showed that in mice recovering from a primary infection with P. berghei yoelli developed immunities against future infections by the same parasite. Acquired immunity of the susceptible hosts after having experience with the infection were shown to be caused by a malaria parasite, usually species specific (Stauber, 1963).

The underlying mechanism of acquired immunity was investigated by a number of authors. Taylor et al. (1949) observed increase of circulating globulin during malarial infection. The gamma globulin was observed to be increased also by Box and Gingrich (1958) just after recovery from malarial infections. Sherman and Hull (1960b) with the help of paper electrophoresis detected the increased level of gamma globulin in P. lophurae infected chicks, whereas, the albumin level was depressed. Similar results were obtained by Sengers (1971) in swiss mice infected with P. berghei. Taliaferro and Taliaferro (1945) showed immunological relationship in Plasmodia. In 1951 Stauber et al., did in vitro agglutinations of erythrocyte free avian Plasmodia, and demonstrated group specific and species specific agglutinins. Sherman and Hull (1961) obtained various active fractions of immune serum by chemical fractionation. Sherman (1964) characterised antigens of P. lophurae. Spira and Zuckerman (1966) studied antigenic analysis of different Plasmodia from monkeys, birds and rodents with the help of immunologic technique. Large number of antigens were

identified. A number of antigens may be shared by different species of plasmodia even by those which are phylogenetically distant from one another but that each species also includes species specific antigens.

Besides this, there are antigens other than those which are an integral part of the parasite cell, known as soluble antigen. This antigen was most readily demonstrable during the acute phase of infection. Eaton (1939) demonstrated the presence of two antigens in the sera of monkeys infected with P. knowlesi. These antigens reacted in a complement fixation test with serum antibodies of monkeys recovered from P. knowlesi infection. Torrey and Kahn (1949) isolated soluble antigens from the plasma of duck acutely infected with P. lophurae. Corwin et al., (1965) observed initial anaemia and subsequent resistance to infection in susceptible duckling which were injected with plasma from ducklings, acutely infected with P. lophurae. Todorovic et al. (1968) isolated antigens from plasma and serum of chickens acutely infected with P. gallinaceum. These antigens were allowed to react in a gel precipitation test with convalescent homologous sera and heterologous sera of human beings, monkeys and rats recovering from infections with P. falciparum, P. vivax, P. malariae, P. knowlesi, P. cynomolgi and P. berghei respectively. A reaction occurred between these antigens and all sera tested. Antigens isolated from erythrocytes of infected chickens, however, reacted only with homologous sera in the above test. Todorovic et al. (1968a) further characterized the soluble antigens termed as exoplasmodial

antigen in chicken serum. Biochemical and biophysical studies revealed that the antigens were proteinaceous in nature and associated with albumin and globulin fractions of serum. Todorovic et al. (1968b) moreover found two fractions in exoplasmodial antigens of P. gallinaceum by electrophoresis. McGregor et al. (1968) noted that soluble antigens were common in Gambian Africans with P. falciparum malaria or recovering from infections. Once the antigen had been eliminated, antibodies were rarely found, indicating that the soluble antigens were weakly immunogenic. Lykins et al. (1971) showed three soluble malarial antigens from the serum of chickens infected with P. gallinaceum and characterization of each antigen.

The role of circulating antibody in malarial immunity was studied by Cohen et al. (1961) in subjects, living in Gambia which is a hyperendemic area of West Africa. The results showed that protective antibodies were primarily associated with 7S gamma globulin. Cohen and McGregor (1963) again showed that 7S gamma globulin fractions of immune Gambian serum possess the protective characteristic against malaria parasite. These findings was supported by Edozien (1964) from Nigerian population. Curtain et al. (1964) also reported the antigen binding capacity of 7S gamma globulin. Abele et al., (1965), by means of immunoelectrophoresis, detected that besides 7S gamma globulin, 19S macroglobulin antibodies were also formed during the course of primary infections in human volunteers. Fluorescent antibody technique indicated that this 19S antibody antivity appeared early in the course of antibody production and was followed by the subsequent

development of 7S antibody activity. Brambell (1958) said that transmission of antibodies in man during prenatal development was possible. In rats and other rodents it becomes chiefly transmitted via the maternal milk (Bruce-chewatt, 1963). Race and Sanger (1958) and Franklin and Kunkel (1958) came to the conclusion that 7S gamma globulin appear to be freely transmitted via the placenta while the 19S gamma globulin was not. It was already shown by McGregor et al. (1963) and McGregoer (1964) that 7S gamma globulin from immune adult Gambians protected Gambian infants from the local strain of P. falciparum. Sadun et al. (1966) showed that immune gamma globulin from West African human beings, protected splenectomised chimpanzees against blood induced infection with P. falciparum. Antibody, present in immune serum combined with the merozoites and prevented reinvasion of red cells, as was noted by Cohen et al. (1969).

The importance of zoonoses in host-parasite relationship

Zoonoses were defined as "Those diseases and infections which are naturally transmitted between vertebrate animals and man" (WHO report, 1959). From the point of host specificity, zoonoses is very important. The more host specific the parasites are, the narrower is the range of the host. The natural occurrence of malarial infection in man by the parasites of other than the human ones is rare. Therefore, the importance of malaria as a zoonoses is not so much (WHO, 1967). However, there are some geographical areas where human infection can be maintained from a

simian reservoir. In 1932, Knowles and Das Gupta reported that P. knowlesi was transmissible to man by blood inoculation. In 1960, an accidental malarial infection of two laboratory workers, handling mosquitoes infected with monkey malaria, proved that transmission of rhesus monkey malaria to human beings by mosquito was possible (Eyles et al., 1960). Schmidt et al. (1961) published a paper on accidental infection of laboratory workers, handling different strains of P. cynomolgi. Coatney et al. (1961) attempted to transmit a strain of P. cynomolgi to man via mosquito and resulted in a low grade infection in one only. They showed that the residence in the human subject did not alter the capacity of the strain to produce characteristic type of infection in the rhesus monkey. Contacos et al. (1962) studied the transfer of M strain of P. cynomolgi from from man to man and capability of the B strain of P. cynomolgi to be transmitted to man by mosquito bite. A discussion of simian malaria as a true zoonoses was carried out by Contacos and Coatney (1963). Six of eleven species of simian malarias had been experimentally transmitted to man either by the transfer of parasitized blood, or by mosquito bite. Bennett and Warren (1965) transmitted a strain of P. cynomolgi, isolated from Macaca irus in Cambodia to man by the bites of infected anopheles mosquito. This parasite was transmitted back to a monkey by infected blood inoculation. Chin et al. (1965) reported a naturally acquired Quotidian type malaria in man transferable to monkey. It was a natural infection of simian malaria parasite in man during his four week stay in Malaya. Poter and Young (1966) reported that the night monkey and titi marmoset were susceptible to

P. vivax. Bray (1968) reviewed the zoonotic potential of malaria. He followed the categories of zoonoses according to Nelson (1960). Coateny (1971) used the term Anthroponeses along with zoonoses. Anthroponeses i.e. the term used for natural transmission of disease from man to other vertebrate. According to him P. cynomolgi, P. inui, P. schwetzi are true zoonoses. P. ovale may be an anthroponeses as well. There are at present several species of plasmodium which may be either a zoonoses, or, an anthroponeses or, both depending on which group of parasites gave its origin.

At present, no instance of bird zoonoses with respect to malaria parasite is known. McGhee's (1950) experiment on experimental infection of mammalian cell by avian malaria parasite is an important step in the evolutionary history. It is not a true zoonoses, as this parasite did not infect human being.

The existence of an animal reservoir of infection complicate malaria control and eradication. If the actual reason of host specificity is detected, it can be applied, to the zoonoses with respect to malaria parasites for its control and erradication.