India and certain parts of the United Provinces, Pusa may claim to be accessible to Bihar and Orissa, Bengal, Assam, parts of Central Provinces and a large section of the United Provinces. Both the centres may, on the other hand, be regarded as being inaccessible to Madras, Mysore, Hyderabad and South India in general. Thus, the charge of being inaccessible may be levelled against any place in India so that it is not quite fair to condemn Pusa mainly on that account. The things that really matter are good facilities, right talent and proper scientific atmosphere : if these are ensured, an institute situated even in the most obscure corner of the country can come to the fore-front, and attract visitors not only from the whole of India but other parts of the World as well.

V. S.

The Malarial Parasites of the Oriental Monkey, *Silenus irus*.*

By Lt. Col. J. A. Sinton, I.M.S.

(*Malaria Survey of India.*)

ONE cannot fail to be struck, in any study of the literature on malaria, by the paucity of the experimental evidence in support of many of the theories put forward. This is mainly due to the fact that all attempts to infect any of the common laboratory animals with the Plasmodia of human malaria have proved unsuccessful. Although much information has been gathered from the researches into avian malaria, there are many disadvantages and limitations in this work. Moreover, it is sometimes difficult to say exactly to what extent the results obtained are applicable to the human problem.

The discovery of the value of malarial infection in the therapy of certain nervous disorders, has opened up a wide field for gathering invaluable experimental evidence. Even under these more satisfactory conditions, the fact that human infections cannot be allowed to run their natural course, in many instances, restricts the usefulness of this line of investigation.

The monkey is the only one of the mammals commonly used for experimental work, in which the presence of natural malarial infection has been confirmed. The fact that such infections occur in a Primate host, suggests that the investigation and study of these conditions would give results more comparable with human infections than could be obtained with the avian type of disease. That malaria in monkeys might provide very valuable material to the malariologist, has long been borne in mind by workers in India.

Very many attempts made by them to discover such infections in the common brown monkey of northern India [*Silenus rhesus* (*Macacus rhesus; Macaca mulatta*)] have proved unsuccessful. This fact has often been deplored, but more recent evidence would appear to indicate that the absence of natural infection in this species of monkey is a fortunate occurrence, from the point of view of the research worker in India. The absence of such natural malarial infections in *S. rhesus* makes available large numbers of uninfected and susceptible Primates for experimentation. Workers on simian malaria in other countries have been greatly hampered in their investigations by the lack of such types of animal.

Malarial infections of monkeys were first recorded by Koch in East Africa in 1898. Since then many species of *Plasmodium* have been reported from various monkeys in different parts of both the Old and New Worlds. Many of the earlier investigators carried out experimental work with such infections. More recently, extensive researches have been reported by workers in America, Malaya and India. The latter work has confirmed the view that from a study of monkey malaria the solutions of many unsolved problems in human malariology may be obtained.

Research in human malaria has shown that the clinical and pathological manifestations of this disease, as well as its reaction to different therapeutic agents, vary with the species of *Plasmodium* responsible for the infection. It is, therefore, essential that an accurate specific identification should be made of the parasite used in any investigation. It is equally important to ensure that the infection studied is due to one species of *Plasmodium*, and one species only. A failure to obtain these conditions has been responsible for many of the con-

* Sinton, J. A., and Mulligan, H. W., *Rec. Mal. Survey India*, 1932, 1933 A, 3, 357–444 ; 1933 B, 3, 719–808.

tradictory statements which have crept into the literature on monkey malaria.

The older literature on the morphology of the Plasmodia of the lower monkeys was in a chaotic condition. This was partly due to the meagre descriptions given by some of the earlier workers of the parasites observed by them. It appears also to have been influenced largely by the fact that mixed infections with two or more species of *Plasmodium* are not rare in these animals, at least among the Oriental *Cercopithecidæ*. Many of the descriptions recorded appear to refer to two different species of parasite, which were present in the same host, but this condition was neither recognised nor suspected.

Sinton and Mulligan have carefully reviewed the literature on the Plasmodia of the lower monkeys. These workers made a special study of the malarial parasites found in the blood of the Oriental monkey, *S. irus* (*Macacus cynomolgus* ; *Pithecus fascicularis*), the crab-eating monkey of Malaya and Burma. Individuals of this species of monkey are not uncommonly infected with malaria, but unfortunately these infections are not infrequently due to two or more species of parasite. The fact that such mixed infections were unsuspected, has given rise to much confusion in the descriptions of the Plasmodia infecting this species of monkey.

The first malarial parasite to be described from the lower Oriental monkeys was *Plasmodium inui* Halberstadter and Prowazek, 1907, from the blood of specimens of *S. irus* from Java and of *S. nemistrinus* from Sumatra. A few months later a new species *P. cynomolgi* Mayer, 1907, was recorded from an infection in *S. irus*, also from Java. Many observers consider that the latter species is identical with the former. Sinton and Mulligan, however, thought that *P. cynomolgi* was probably a distinct species, but placed it provisionally as a variety of *P. inui*. The reason for this was that, while they had had ample opportunity of studying *P. cynomolgi*, both in natural and in experimental infections, yet they had to depend for information about *P. inui* on descriptions given by other workers. As will be seen later, their views as to the specific identity of *P. cynomolgi* have since been confirmed.

Sinton and Mulligan proved that mixed plasmodial infections were not uncommon in *S. irus* in nature, and they managed to separate from the blood of this monkey two distinct species of *Plasmodium*. These parasites they identified as *P. inui* var. *Cynomolgi* Mayer, 1907, and a new species, *P. knowlesi* Sinton and Mulligan, 1932.

Plasmodium knowlesi does not appear to be very closely related to any of the three common malarial parasites of man, although it shows some morphological characters resembling each of these. This species was proved to have an asexual cycle of 24 hours' duration. While infection with this parasite has apparently little clinical effect on its natural host, *S. irus*, it produces quite a different picture when a susceptible host, such as *S. rhesus*, is infected experimentally with it. In the latter species of monkey, it causes very severe symptoms, often hæmoglobinuria, and almost invariably produces death with pernicious symptoms, if the infection be untreated. Knowles and Das Gupta have managed to transmit this infection to man by blood inoculation.

Plasmodium cynomolgi very closely resembles in its morphology *P. vivax*, the benign tertian parasite of man. It has a 48-hour asexual cycle. The clinical symptoms produced in *S. irus* and in *S rhesus* are of a mild character. This infection has been transmitted experimentally from monkey to monkey by the bites of infected specimens of *Anopheles annularis* and *A. subpictus*.

Since Sinton and Mulligan recorded these two species of *Plasmodium* from *S. irus*, a third species has been detected in their laboratories from the same species of natural host. The infection was also a mixed one originally, but a pure infection has now been isolated experimentally in *S. rhesus*. This parasite appears to be identical with *P. inui* sens. restr., as described by Halberstadter and Prowazek and by Mathis and Leger.

The morphology of this parasite has several points of resemblance to *P. malariæ*, the quartan parasite of man, but some forms more closely resemble *P. vivax*. The infection produces mild effects in *S. irus* and in *S. rhesus* and tends to be very chronic. The duration of the asexual cycle of *P. inui* sens. restr. was usually said to be 18 hours, but the evidence in support of this statement was very unsatisfactory. A careful study of long series of blood films taken every few hours from monkeys infected with this third parasite, shows that its asexual cycle has a periodicity of 72 hours.

These findings prove definitely that three species of *Plasmodium* occur naturally in the blood of the Oriental monkey, *S. irus* from Malaya, namely:—

(*a*) *P. knowlesi* Sinton and Mulligan, 1932, having a 24-hour asexual cycle;

(*b*) *P. cynomolgi* Mayer, 1907, having a 48-hour asexual cycle; and

(*c*) *P. inui* Halberstadter and Prowazek, 1907, having a 72-hour asexual cycle.

All these species are easily transmissible by blood inoculation to *S. rhesus*, and pure infections are being maintained in the laboratories of the Malaria Survey of India, Kasauli.

The facts (*a*) that the common brown monkey of Northern India (*S. rhesus*) is susceptible to experimental infection with these three species of simian Plasmodia, (*b*) that these monkeys appear to have no malarial infection in nature, and (*c*) that they are easily and cheaply available in India, open up a wide field in this country for the investigation of many important malaria problems. Such facilities are available in few or no other countries of the world.

Permeability of Protoplasm—A Probable Factor in Transpiration.

(Being a Study of Transpiration Response under Ultra-Violet Radiation.)

By B. N. Singh, D.Sc., and S. C. Das Gupta, B.Sc.

(*Institute of Agricultural Research, Benares Hindu University.*)

OF the various factors that appear to control transpiration it is the atmospheric ones which have received by far the greatest attention and much stress has been laid to show that transpiration is a relatively simple process, probably the simplest of all the plant functions yet known, governed largely by the environic complex. The behaviour of transpirational loss of water under controlled environment, however, has led Plant Ecologists to believe that there exist some internal factor or factors in transpiration, the nature of which does not seem to be well understood.

The present brief note is an outcome of some observations on the influence of ultra-violet radiation upon transpiration, and when taken in conjunction with an independent parallel study on permeability in plant tissues, seems to provide repeated conclusions of an uncommon interest, revealing that protoplasmic permeability performs a regulatory function in transpiration.

While investigations relating to the influence of ultra-violet radiation are known to exist, in an incomplete form though, upon such individual functions as photosynthesis, respiration and permeability in plants, to our knowledge, no observations appear to have been made so far as to the influence of such rays upon transpiration. The observations herein recorded are an attempt in this direction.

The procedure of experimentation in brief consists in selecting healthy mature cut twigs of *Cajanus indicus*, *Triticum vulgaris* and *Andropogan sorghum*, fixing them in hermetically sealed glass vessels containing sufficient water in which the cut end always dips, and estimating the hourly loss of water after the method already described elsewhere.[1] The experimental material is subjected to desired doses of 0, 5, 10, 15, 20, 30 and 40 minutes exposure to ultra-violet radiation.

On plotting the mean transpiration values for the treated plants obtained for a period of five successive hours against time (Fig. 1) it is noticed that the general nature of the response in all the three cases under consideration is similar in spite of material differences. We shall, therefore, try to explain the phenomenon on the basis of the data obtained for any one crop.

A reference to Fig. 2 would indicate that transpiration of irradiated plants exhibits two maxima, one under ten minutes treatment while the other under thirty minutes exposure. Both these pitches are preceded and followed by a decline in the transpiration curve which, in general, shows an unusual contrast to the curves of transpiration obtained for the control plants.

The increase or decrease in the rate of transpiration of treated plants as against the control, may be explained on the basis of certain imminent possibilities:—

(i) Variation in the supply of water from the roots.

[1] Singh, B. N., "On the Use of Bates Evaporimeter and Evaporimeters in general in Studies on Plant Transpiration," *Journ. Ind. Bot. Soc.*, 1924.