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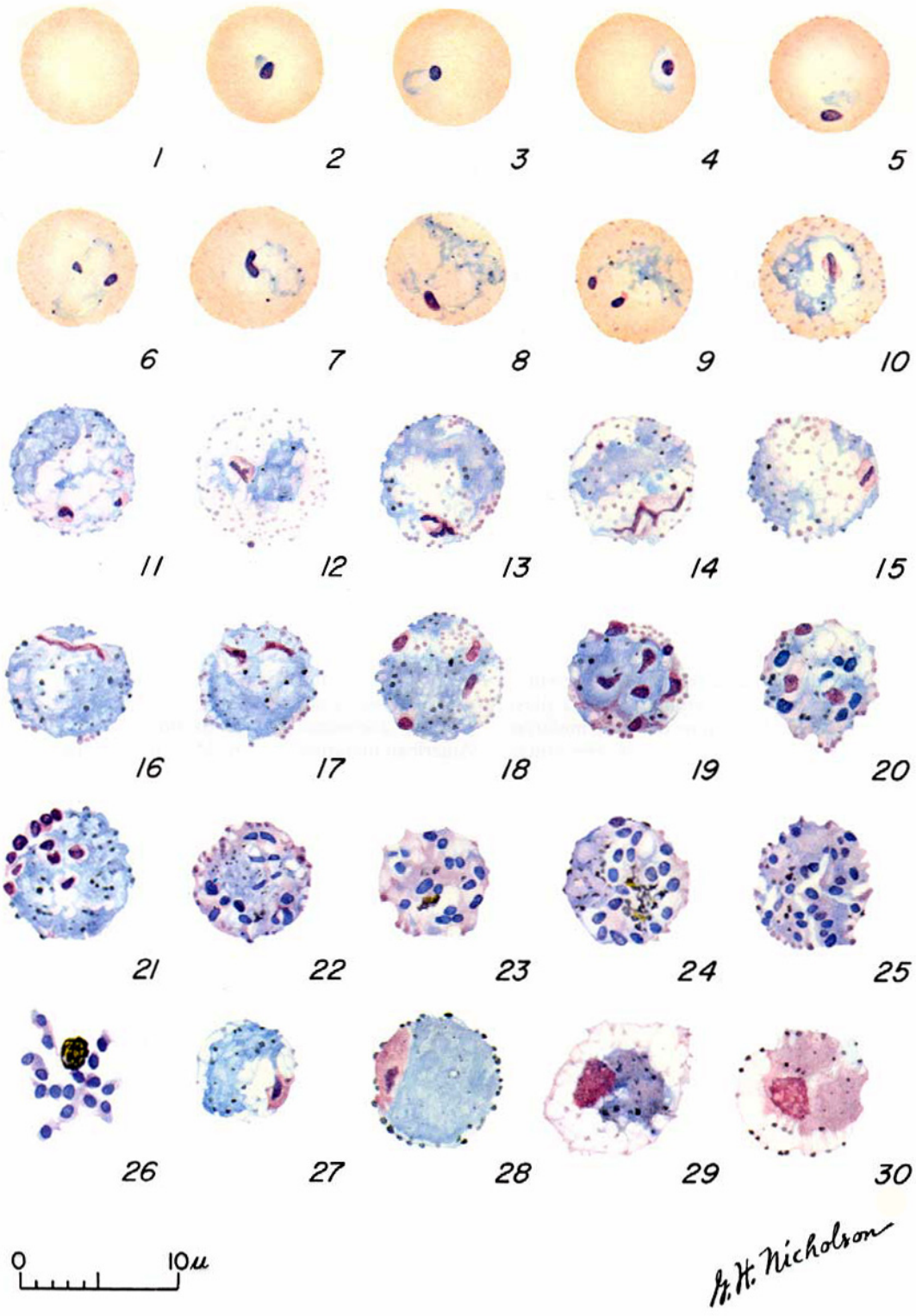
Plasmodium youngi Eyles, Fong, Dunn, Guinn, Warren, and Sandosham, 1964

THE first report of a true malaria from the gibbon was that of Rodhain who described *Plasmodium hylobati* in 1941. Earlier, Fraser (1909) mentions finding a "malaria-like parasite" *Plasmodium kochi* in *Hylobates symphalangus* (= *Symphalangus syndactylus)* in Malaya. *Plasmodium kochi* is actually a hepatocystis considered generally to be limited to the monkeys. However, Shiroishi *et al* (1968) reported *Hepatocystis sp.* in *Hylobates concolor* from northern Thailand and therefore the Fraser parasite could have been a representative of either genus. It probably was a plasmodium since we know now that true malarias are common in the gibbons of peninsular Malaysia (Eyles *et al,* 1964; Warren *et al,* 1965, 1966) and in Thailand (Ward and Cadigan, 1966; Cadigan *et al,* 1969).

In May of 1962, personnel of the Far East Research Unit (NIH) located in Kuala Lumpur, Malaysia, obtained a young gibbon *(Hylobates lar)* which had been captured in the state of Kalantan in peninsular Malaysia. The animal harbored a true P*lasmodium* which did not fit the description of *P. hylobati.* Eyles and his coworkers transferred the parasite to other gibbons and after careful study concluded it was a new species. They named the parasite *Plasmodium youngi* in honor of the American malariologist, Dr. Martin D. Young.



PLASMODIUM YOUNGI

Cycle in the Blood
PLATE XXIV

The youngest parasites are frequently ring-shaped and measure about 2 μ. The nucleus is generally single but there may be up to four nuclei of unequal size (not shown on plate). Sometimes marginal (applique) forms are present, a characteristic of *P. coatneyi* of macaques and of *P. falciparum* of man. Stippling of the Schüffner type appears as the young forms mature and is prominent in cells harboring old trophozoites (Fig. 10). Host cells are not enlarged. The older trophozoites are amoeboid (Figs. 11, 12). The cytoplasm stains a pale blue; pigment becomes heavier and is seen as yellowish-brown granules (Figs. 15, 16). Stippling is fairly prominent and there is no host cell enlargement. The original describers made a point of the latter fact because their figures gave the illusion that the host cell was enlarged.

The cytoplasm of the young schizont takes a slightly darker stain than the earlier forms and may fill the host cell completely. The pigment collects into larger granules and Schüffner's stippling is prominent (Figs. 17-19). The older schizonts appear to have depleted the host cell cytoplasm to the extent that it stains poorly; the cytoplasm of the parasite takes a light blue stain. The merozoites may number from 12 to 20 with an average of about 14. The pigment is concentrated in large yellowish-brown granules and comes together in a single mass during the final stages of schizogony (Figs. 23-26).

The cytoplasm of the young gametocytes takes a deep blue stain and displays a prominent red nucleus. Schüffner's stippling may be prominent. The cytoplasm of the macrogametocyte is compact and stains a pale blue with prominent pigment sometimes located toward the periphery of the parasite. The nucleus is generally eccentric, takes a deep red stain, and encloses a deeper staining, bar-like area. The adult forms fill the host cell (Fig. 28). The cytoplasm of the microgametocyte stains reddish-purple and exhibits a large deep reddish-pink nucleus sometimes with a deeper staining bar-like area. The black pigment is prominent and Schüffner's stippling collects toward the periphery of the host cell. The parasite may not fill the host cell (Figs. 29, 30).

The asexual cycle follows a tertian periodicity.

Sporogonic Cycle

The natural vector of *P. youngi* is unknown but is likely to be a member of the leucosphyrus group of anopheline mosquitoes. Eyles *et al* (1964) found *A. maculatus* partially susceptible in that oocysts developed slowly but failed to produce sporozoites. Warren *et al* (1965) also found only partial development in *A. sundaicus, A. balabacensis introlatus,* and *A. maculatus* (see Table 19).

Cycle in the Tissue

The tissue stages of this parasite are unknown.

Course of Infection

According to Eyles *et al* (1964) gibbons *(H. lar)* which received their infection via inoculation of parasitized blood exhibited peak parasitemias of 43,000 to 130,000 per mm^3 12 to 16 days following inoculation. Although the parasitemia declined after the peak, parasites persisted in the circulating blood for up to 192 days. Infections in these animals were more severe than usually seen in malaria infections in lower primates. The maximum temperature

PLATE XXIV.—*Plasmodium youngi*.

Fig. 1. Normal red cell.
Figs. 2-5. Young trophozoites.
Figs. 6-15. Growing trophozoites.
Fig. 16. Mature trophozoites.
Figs. 17-22. Developing schizonts.
Figs. 23-26. Nearly mature and mature schizonts.
Figs. 27-28. Young adult and mature macrogametocytes.
Figs. 29-30. Young adult and mature microgametocytes.

encountered was 106.5° F. The animals were clinically ill, anemic, and listless. It is not unlikely that this parasite may actually incapacitate some animals in the wild.

Subsequent to the work of Eyles *et al* (1964) blood-inoculated infections have been studied in 7 additional gibbons and the data pooled. The median parasitemia curve for the 12 animals, during the first 60 days of patent parasitemia (Fig. 36), shows that a peak count of approximately 30,000 per mm^3 occurred on day 13. The parasite level then declined to about 100 per mm^3 by day 50, followed by a secondary rise.

In instances where blood parasitized with *P. youngi* has been inoculated into rhesus monkeys no infection resulted. No attempts have been made to infect man with this parasite.

Host Specificity

The normal host of *P. youngi* is the white-handed gibbon *(H. lar).* The infection has been transferred by inoculation of parasitized blood to *H. concolor* and another gibbon, possibly *H. agilis.* Neither of these animals developed an intense parasitemia signifying the generally held belief that each of the malarias of gibbons is more or less host specific.

The natural vector is unknown. Experimentally, *Anopheles maculatus, A. sundaicus,* and *A. b. introlatus* have been proven susceptible to at least partial development of the parasite (Eyles *et al,* 1964; Warren *et al,* 1965).

Antigenic Relationships and Immunity

No antigen-antibody studies have been carried out. There appears to be little cross-immunity. between *P. youngi* and the other malarias of gibbons, according to Warren *et al* (1966). Those investigators were able to obtain a full-blown infection with *P. jefferyi* in a gibbon that had had prior infections with both *P. youngi* and with *P. eylesi.*

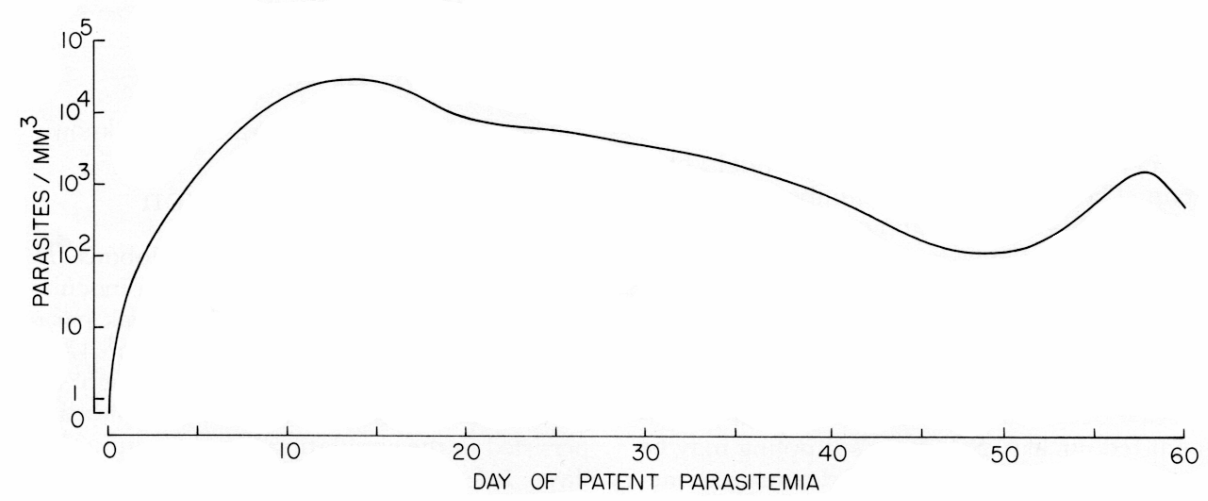


FIGURE 36.—Median curve of *Plasmodium youngi* parasitemia in 12 gibbons, *Hylobates lar*, infected by the inoculation of parasitized blood.

TABLE 19.—Oocyst diameters of *Plasmodium youngi* in *Anopheles b. introlatus, A. maculatus,* and *A. sundaicus.*

Days after infection	*A. b. introlatus*			*A. maculatus*			*A. sundaicus*		
	No.	Range	Mean*	No.	Range	Mean	No.	Range	Mean
6.5	13	12-27	18	9	15-22	21			
7.5				10	22-30	27	13	15-30	24
8.5	5	20-27	23						
9.5				1	30	30			
10.5									
11.5				8	30-60	44			

* Measurements expressed in microns.

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