

ON THE MORPHOLOGY AND LIFE HISTORY OF *SPIROCHAETA DUTTONI*

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In the course of our experimental study of the spirochaete of African Relapsing fever, *Spirochaeta duttoni*,¹ numerous films were made of the blood, and of the organs, of animals in the different stages of the disease, with a view of ascertaining the life-history of the parasite. Considerable uncertainty still exists concerning the morphology and the life cycle of the whole group of spirochaetes. While Novy and Knapp² deny that the parasites undergo any morphological changes, Prowazek,³ in his work on fowl spirochaetes, gives them an undulating membrane and a definite nuclear apparatus, and also describes intra-cellular stages. One terminal flagellum was observed by Novy and Knapp in *Spirochaeta obermayeri*, and by Stephens⁴ in *Spirochaeta duttoni*; Zettnow⁵ on the other hand describes peritrichal flagella in *Spirochaeta duttoni*, and Borrel⁶ in fowl spirochaetes.

The stain employed in the present work was Giemsa's modification of Romanowsky's stain, in dry films. Wet films were not found to possess any particular advantage when working with this parasite.

The spirochaete consists of a darkly stained central core, which is surrounded by a light-stained periplastic sheath. This sheath extends beyond the central chromatic core, and is drawn out at one end into an elongated filament, thus forming a structure which has been described by various observers as a terminal flagellum. All attempts

to demonstrate peritrichal flagella, either in fresh or in stained specimens, have completely failed. The central core, or chromatic part, does not always stain uniformly, but in certain parasites lighter and darker areas are noticeable, either throughout the whole length or confined to one part of the parasite (figs. 1, 2). Very frequently, especially in spirochaetes which are disappearing from the circulation, the whole chromatic core seems to be broken up into an irregular number of granules (fig. 3). In this stage of infection the spirochaetes often show one or more swellings, either in the centre or at one end (figs. 4, 5). A fairly constant appearance, which has been previously described by various observers in *Spirocheta obermeieri* and *Spirocheta duttoni*, is a small unstained transverse band situated at about one-third of the length of the parasite (fig. 6).

A considerable amount of work was done with the object of demonstrating an undulating membrane. Although in specimens stained with Giemsa's solution an appearance was sometimes seen which resembled an undulating membrane, this was, in my opinion, due only to the flattening out of the spirals of the parasite. In wet films, even after a prolonged staining by Heidenhain's method, no trace of an undulating membrane could be seen.

The division of *Spirocheta duttoni* is, as a rule, transverse. The parasites increase in length and become thinner in the middle; this thinner part then elongates more and more until the two individuals separate (figs. 7, 8). It is very probable that the unstained area frequently seen in the normal parasite (fig. 6) is the point of the future elongation and subsequent transverse division. Occasionally, longitudinal division was seen to take place, especially at the time of the disappearance of the parasites from the peripheral circulation, and in this stage of the infection in the organs the parasite was seen to increase in thickness, the division commencing at one end of the spirochaete and gradually extending along its entire length (fig. 9). Judging from the scantiness of the parasites at this stage, it would appear that this process is a comparatively rapid one. In rare instances, at this stage of the disease, parasites were seen being engulfed by phagocytes.

A striking appearance as depicted in fig. 10 was, on rare occasions, seen in the blood. Two spirochaetes were observed lying close to each other, touching at certain points. The one was stained

dark red with Giemsa, the other light blue, with apparently no chromatic core, but showing an irregular number of dark red granules situated at the points at which the two spirochaetes were in apposition. We are inclined to explain this appearance as conjugation.

Prowazek describes intra-cellular stages of *Spirocheta gallinarum* in the red blood cells. We were able to observe the same phenomenon in rare instances with *Spirocheta duttoni* just before the crisis set in (fig. 11).

Although the appearance of the parasites in the peripheral blood seemed fairly uniform, striking changes were observed in parasites seen in the organs, notably in the spleen, bone marrow, and liver.

Numerous spirochaetes, especially just before the crisis, when the blood was still swarming with parasites (principally in the spleen and bone marrow, rarely in the liver), were seen coiling themselves up (fig. 12), a few presenting a swollen appearance (fig. 13), the majority gradually becoming thinner and rolling themselves up into more and more complicated skein-like forms (figs. 14, 15) which seemed to become more irregular as the time of the crisis drew near. The majority of these forms were devoured by the phagocytes of the spleen, and at the time of the crisis the spleen cells were observed to be gorged with degenerated spirochaetes. In animals in which the spleen had been removed an analogous process took place in the liver.

A few similarly shaped parasites underwent a remarkable change:—The outline remained more regular for a time, and the parasite surrounded itself with a thin cyst wall, the interior of the cyst being filled with a faintly blue stained plasma (fig. 16). These forms, in scanty numbers, were to be seen even after all the other forms had disappeared. They apparently undergo further changes, as the shape of the parasite becomes more and more indistinct and at a still later stage only the cyst filled with small red granules persists.

We were unable to trace the further development of these forms as in specimens stained by Giemsa's method it is impossible to differentiate them from blood platelets and other constituents. The fact that the filtrate of spirochaetal blood through a Berkefeld filter is infective suggests that these small granules may be the forms which pass through the filter and give rise to a fresh infection.

The life history of the spirochaete might be thus summarised:—Just before the crisis the spirochaetes disintegrate, certain of them coiling up into skeins, the majority of which are phagocytosed by the spleen. Some of them become encysted and break up into very small bodies, out of which the new generation of spirochaetes is evolved.

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- Some forms described in the present paper were observed by this author.

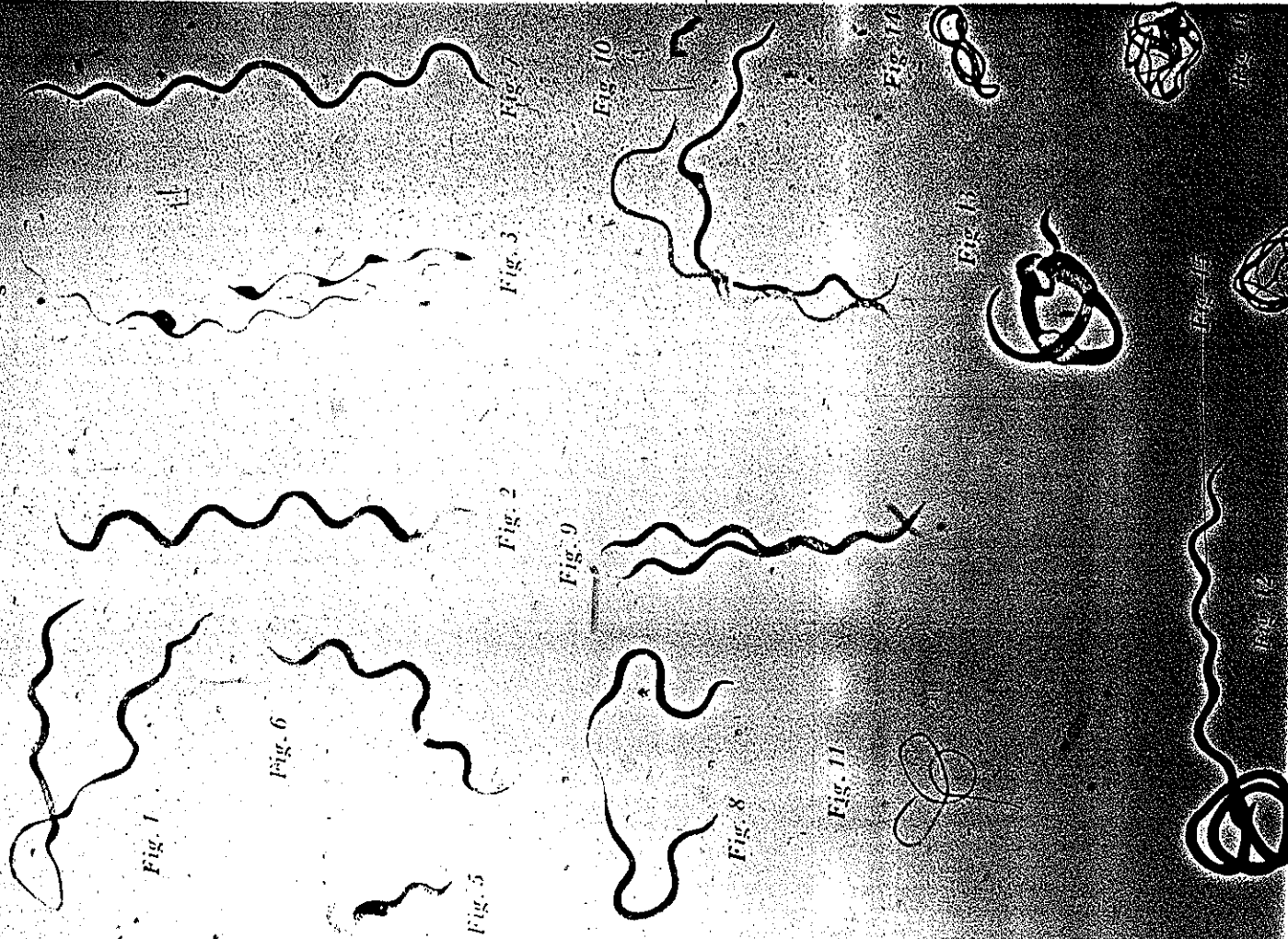
EXPLANATION OF PLATE

The accompanying drawings were done with a Zeiss apochromatic objective 2 mm. aperture 14, ocular 18. Drawn to the scale of 4,500.

Figs. 1 to 12.—From the peripheral circulation of infected monkeys and rats, respectively.

Fig. 13.—From the liver of an infected monkey.

Figs. 14 to 16.—Forms found in the spleen.



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