CRESCENTIC BODIES IN ÆSTIVO-AUTUMNAL MALARIA; THEIR MIGRATION AND ATTACHMENT TO THE SURFACE OF THE RED CORPUSCLE.*

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PLATE 13 AND 14.

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Æstivo-Autumnal Parasites.

Since 1879, when malarial parasites were first described, the consensus of opinion has been that the parasites are intracellular, and that each parasite, when young, enters a red corpuscle, staying there until it dies or segmentation takes place, the destruction of the corpuscle corresponding with the segmentation of the parasite. But this is not the case. All malarial parasites are extracellular, that is they are attached to the external surface of the infected corpuscle, and each parasite destroys several red corpuscles. One may trace the destruction of corpuscle after corpuscle by the migrating parasites of æstivo-autumnal infections.

The parasites usually present in the blood of æstivo-autumnal infections are the ring-forms and crescentic bodies. When round bodies are present, they are usually developmental forms of the crescent. The crescent may present an ovoid appearance (1) when bent on itself and viewed from the convex side and (2) when contracted. When the parasite is contracted, the width of the body is increased.

Crescentic Bodies.

The shape of the crescent is similar to that of a caterpillar; the extremities are generally blunt, but one or both may be pointed. That the body of the parasite is wider than it is thick is illustrated by the appearance of one when bent on itself (Figs. 6, 37, and 49).

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Attachment of the Crescent to the Red Corpuscle.—The parasite is extracellular and wraps itself around the corpuscle as a worm wraps itself around a berry (Figs. 1 to 10 and 36). The attachment of these bodies to the external surface of the red corpuscle is demonstrated by the following facts. (*a*) When attached to a corpuscle and seen in profile, the poles of the parasite may be observed extending beyond the periphery of the infected corpuscle in many instances (Figs. 1 to 3, 5 to 8, and 10). (*b*) When viewed from above, one occasionally sees the poles of the attached crescent extending beyond the periphery of the corpuscle (Figs. 9, 12, 26, 30, 32 to 34, and 38 to 40), and in these instances it is often possible to trace the outline of the corpuscle crossing the body of the parasite (Figs. 32, 34, 38, and 39). In rare instances the body proper of the crescent may be seen protruding beyond the periphery of the infected corpuscle (Fig. 48; the dotted line shows where the corpuscle crosses the parasite). (*c*) Occasionally the corpuscle may be seen situated between the body proper and the clubbed end of a crescent bent on itself (Fig. 37).

Ordinarily the corpuscle appears only on one side of the crescent, especially after the corpuscle has been decolorized; but occasionally one may see the corpuscle projecting on either side of the crescent. In these instances the parasites show but little curving and one views them from above (Figs. 13 to 16, 18, 19, 26 to 28, 31, 33, 35, 39, and 40). In the majority the hemoglobin of the corpuscles is more or less intact. Under such circumstances, where the parasite is attached to its full extent, the picture is what one would expect, as the healthy corpuscle is more elastic than the parasite, and spreads out in all directions when pressure is exerted.

Hemoglobin Mounds.

The mounds of hemoglobin substance which the parasite encircles with its cytoplasm for the purpose of attachment and assimilation are easily demonstrated when seen at the periphery of the parasite (at o in Figs. 1 to 3, 5, 6, 29, 32, 35, 47, and 49). These mounds are usually decolorized before the corpuscle itself, but occasionally they may be seen not yet decolorized, in connection with parasites attached to corpuscles showing varying stages of dehemoglobinization, and to corpuscular skeletons (Figs. 41, 43, and 46, at o).

Migration of the Crescentic Bodies.

Crescentic bodies go through migratory stages similar to those of other malarial parasites, and it is possible to find all the stages in one film, especially if the infection is a heavy one and quinine has not been given.

Evidence of Migration.—That the crescentic bodies destroy more than one red corpuscle is strongly suggested by the following facts. (*a*) Heavily pigmented parasites may be found attached to newly invaded red corpuscles. By newly invaded, I mean instances where the hemoglobin appears to be as yet unaltered by the action of the attached parasites (Figs. 1 to 5, 8 to 10, 12, 14 to 20, 22 to 28, and 56). The pigmentation of these parasites is evidence of previous attachments. (*b*) In the same film pigmented parasites are observed on red corpuscles showing varying degrees of dehemoglobinization (Figs. 6, 7, 11, 21, 29 to 40, 47 to 49, and 53). (*c*) Pigmented parasites occur on corpuscular skeletons or remnants of red corpuscles which have been altered by the action of the attached parasites (Figs. 41 to 46). These skeletons may also be seen free from parasites. (*d*) In the same film pigmented parasites are found free from red corpuscles (Figs. 50 to 52, 54, and 55). The pigmentation of these parasites is evidence of previous attachments.

Occasionally a crescent is seen in the act of attaching itself to a fresh red corpuscle before it has conformed itself to the curved surface of the corpuscle (Fig. 56; a careful examination of this figure will show clearly the attachment of the parasite to the corpuscle).

I have never observed the migratory stages in connection with the crescents after the administration of quinine. Possibly the continued use of quinine may inhibit the migration of the crescents without causing their immediate destruction, as they may be present in the blood for some time after quinine has been used without any appreciable anemia resulting. Migration of the crescentic bodies is less frequently observed in the blood than is migration of the young forms of the æstivo-autumnal parasite. This finding might be explained by the fact that the infection is usually recognized before the appearance of the crescents and vigorous treatment instituted. But the large amount of pigment which most of these bodies contain

would indicate that they may do considerable damage before their destructive action is restrained.

A heavily pigmented, full grown parasite attached to a red corpuscle the hemoglobin of which is intact, or nearly so, should suggest that the parasite must have obtained that pigment from another source, and that source was undoubtedly another red corpuscle. It seems to me that this is convincing evidence of parasitic migration.

There is considerable evidence of the migration of the crescentic bodies in the observations of several writers. Free crescents and heavily pigmented crescents attached to healthy appearing red corpuscles have been described and frequently illustrated. Osler[1] pictures free pigmented crescents. Laveran[2] pictures free pigmented crescents and a pigmented parasite attached to a healthy appearing red corpuscle. Mannaberg[3] pictures free crescents and pigmented crescents attached to healthy appearing red corpuscles. Canalis[4] states that the crescents decolorize the red corpuscles and finally become free in the blood, and he illustrates[5] free crescents and pigmented crescents attached to healthy appearing red corpuscles. Thayer and Hewetson,[6] in describing crescents, state that in some instances all trace of the corpuscle may be absent, and Thayer[7] gives figures showing a pigmented crescent on a corpuscle that has not been decolorized, and two free crescents. Manson[8] pictures a pigmented crescent attached to a healthy appearing red corpuscle. Marchiafava and Bignami[9] show a pigmented cres-

[1] Osler, W., quoted from Laveran, A., Paludism, translation by Martin, J. W., London, 1893, 41, Fig. 7, *F* and *H*.

[2] Laveran, A., Paludism, translation by Martin, J. W., London, 1893, 18, Fig. 3.

[3] Mannaberg, J., The malarial parasites. A description based upon observations made by the author and by other observers, translation by Felkin, R. W., London, 1894, Plate 2, Figs. 51 and 52, Plate 4, Figs. 35 to 42, 53, and 54.

[4] Canalis, P., quoted from Thayer, W. S., and Hewetson, J., The malarial fevers of Baltimore, *Johns Hopkins Hosp. Rep.*, 1895, v, 24.

[5] Canalis, P., Studi sulla Infexione malarica. Sulla varièta parassitaria delle forme semilunari di Laveran e sulle fibbri malariche che da esse dipendono, *Arch. sc. med.*, 1890, xiv, 75, Plate 3 C, Figs. 4, 5, and 12, 3 B, Figs. 7 to 9.

[6] Thayer, W., and Hewetson, J., The malarial fevers of Baltimore, *Johns Hopkins Hosp. Rep.*, 1895, v, 93.

[7] Thayer, W. S., Lectures on the malarial fevers, New York, 1897, Plate 3, Figs. 29, 33, and 41.

[8] Manson, P., Tropical diseases: a manual of the diseases of warm climates, London, Paris, New York, and Melbourne, 2nd edition, 1900, 14, Fig. 9.

[9] Marchiafava, E., and Bignami, A., Malaria, in Stedman, T. L, Twentieth century practice, New York, 1900, xix, Plate 2, Figs. 54, 61, 64, and 65.

cent attached to an apparently healthy red corpuscle, as well as free crescents. Celli[10] pictures a pigmented crescent attached to a healthy appearing red corpuscle and a free crescent. Brumpt[11] pictures a free crescent and Thompson[12] heavily pigmented crescents attached to red corpuscles whose hemoglobin appears to be intact, as well as crescents free from red corpuscles.

EXPLANATION OF PLATES.

PLATE 13.

Magnification, × 1,684.

FIGS. 1 to 5. Heavily pigmented crescents attached to the periphery of healthy appearing red corpuscles, the hemoglobin of which appears to be intact. Hemoglobin mounds encircled by the cytoplasm of the parasites may be seen at o.

FIG. 6. A heavily pigmented crescent attached to a slightly decolorized red corpuscle. Hemoglobin mounds may be seen at o and an attaching filament from the cytoplasm of the parasite may be seen at x. This filament extends beyond the periphery of the infected corpuscle.

FIG. 7. A heavily pigmented crescent attached to a slightly decolorized red corpuscle. The poles of the crescent may be seen extending outside the periphery of the corpuscle.

FIG. 8. A heavily pigmented crescent attached to a healthy appearing red corpuscle, the hemoglobin of which appears to be intact. An attaching filament extending beyond the infected corpuscle is seen at x.

FIG. 9. A heavily pigmented parasite attached to a healthy appearing red corpuscle. The clubbed ends of the crescent may be seen bent over the edge of the infected red corpuscle.

FIG. 10. A heavily pigmented parasite attached to a healthy appearing red corpuscle. The clubbed end at the lower part of the picture is seen extending beyond the periphery of the infected corpuscle.

FIGS. 11 and 12. Heavily pigmented parasites attached to fairly healthy appearing red corpuscles.

FIG. 13. Crescentic body attached to a red corpuscle showing Schüffner's granules.

FIGS. 14 to 21. Heavily pigmented parasites attached to healthy appearing red corpuscles.

FIG. 22. A heavily pigmented crescent attached to a healthy appearing red corpuscle. A flagellum taking the nuclear stain may be seen at x.

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[10] Celli, A., Malaria, New York, 1901, 45, Figs. N and R.

[11] Brumpt, É., Paludisme, Précis de parasitologie, Paris, 2nd edition, 1913, Plate 1, Fig. 14.

[12] Thompson, D., The origin and development of gametes (crescents) in malignant tertian malaria: some observations on flagellation, etc., *Ann. Trop. Med. and Parasitol.*, 1914–15, viii, 85, Plate 5, Figs. 12 to 14 and 28 to 32.

FIGS. 23 to 29. Heavily pigmented crescents attached to red corpuscles apparently containing a normal amount of hemoglobin. Fig. 29 shows hemoglobin mounds at o.

FIG. 30. A heavily pigmented crescent attached to a corpuscle partly dehemoglobinized. What is probably an attaching filament, arising from the cytoplasm of the parasite, may be seen extending from x to x.

FIGS. 31 to 35. Heavily pigmented crescents attached to red corpuscles in varying stages of dehemoglobinization. Hemoglobin mounds may be seen at o. In Figs. 32 to 34 the poles of the parasites may be seen to extend beyond the periphery of the corpuscles to which the parasites are attached. In Fig. 33 one of Maurer's rings may be seen in the infected corpuscle at x. In Fig. 35 an attaching filament arising from the cytoplasm of the parasite may be seen at x.

PLATE 14.

Magnification, × 1,684.

FIG. 36. A heavily pigmented crescent wrapped around a decolorized red corpuscle. The external relation of this parasite to the corpuscle is clearly shown.

FIG. 37. A heavily pigmented crescent attached to a decolorized red corpuscle. At x the corpuscle may be seen between the body of the parasite and one of the poles. This parasite could not be within the infected corpuscle.

FIGS. 38 and 39. Heavily pigmented crescents attached to decolorized red corpuscles. The poles of the attached parasites may be seen extending beyond the periphery of the unbroken outline of the infected corpuscles. The outline of the corpuscles may be traced through the bodies of the attached parasites.

FIG. 40. A heavily pigmented crescent attached to a decolorized red corpuscle. At *A* the crescent is bent over the periphery of the infected corpuscle.

FIGS. 41 to 46. Heavily pigmented, healthy appearing crescents attached to corpuscular skeletons. Note the general semilunar appearance of the skeletons. Hemoglobin mounds may be seen at o. Fig. 42 shows the crescent bent on itself. Attaching filaments arising from the cytoplasm of the crescent and attached to the corpuscular skeleton may be seen at x in Fig. 46.

FIG. 47. Pigmented crescents attached to decolorized red corpuscles. Hemoglobin mounds may be seen at o.

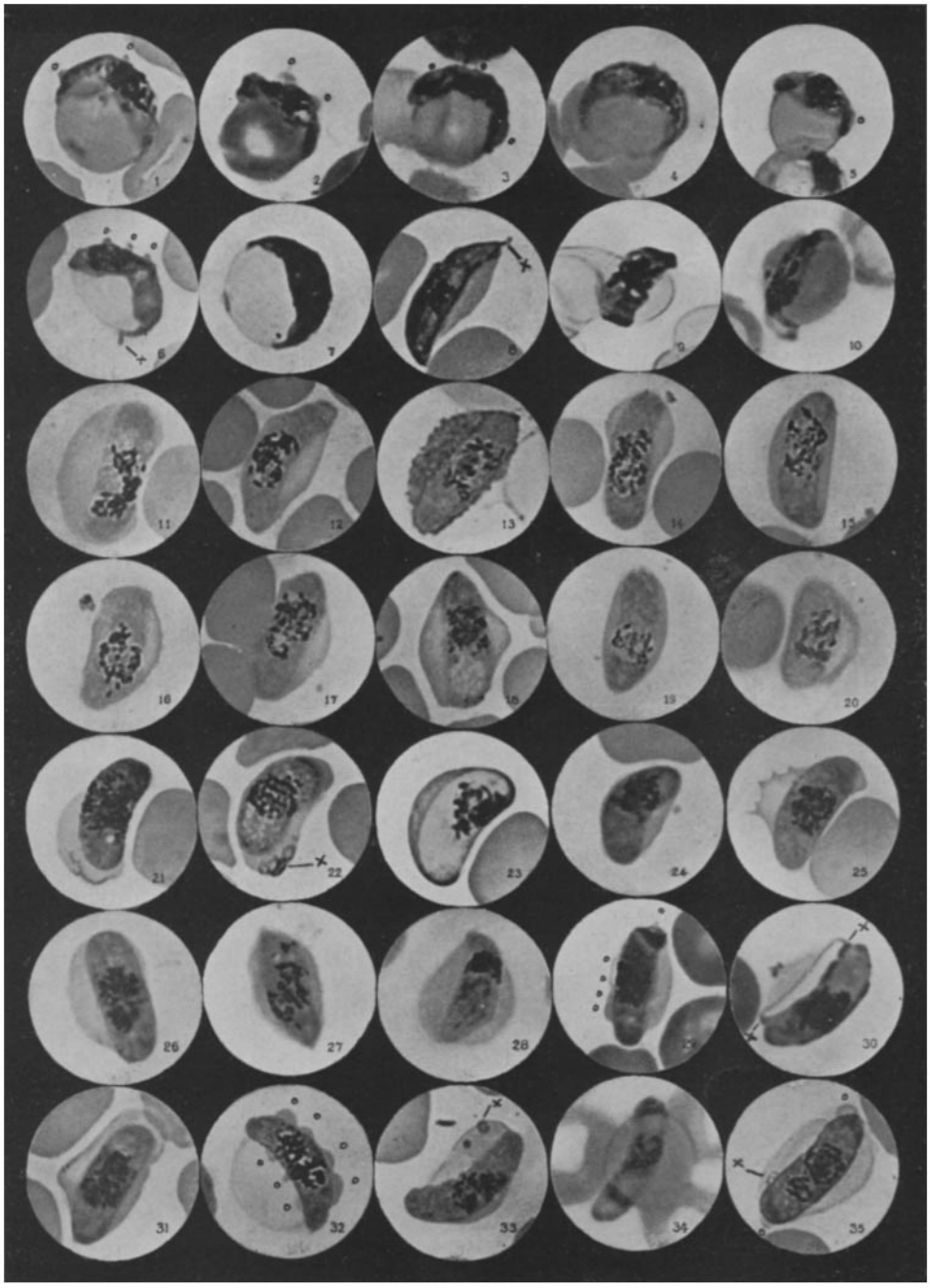
FIG. 48. A pigmented crescent attached to a decolorized red corpuscle. The body of the attached crescent extends beyond the periphery of the decolorized corpuscle. The dotted line marks where the corpuscle crosses the parasite.

FIG. 49. A pigmented crescent attached to a decolorized red corpuscle. The crescent is bent on itself, thus giving the appearance of a double bib. A hemoglobin mound may be seen at o.

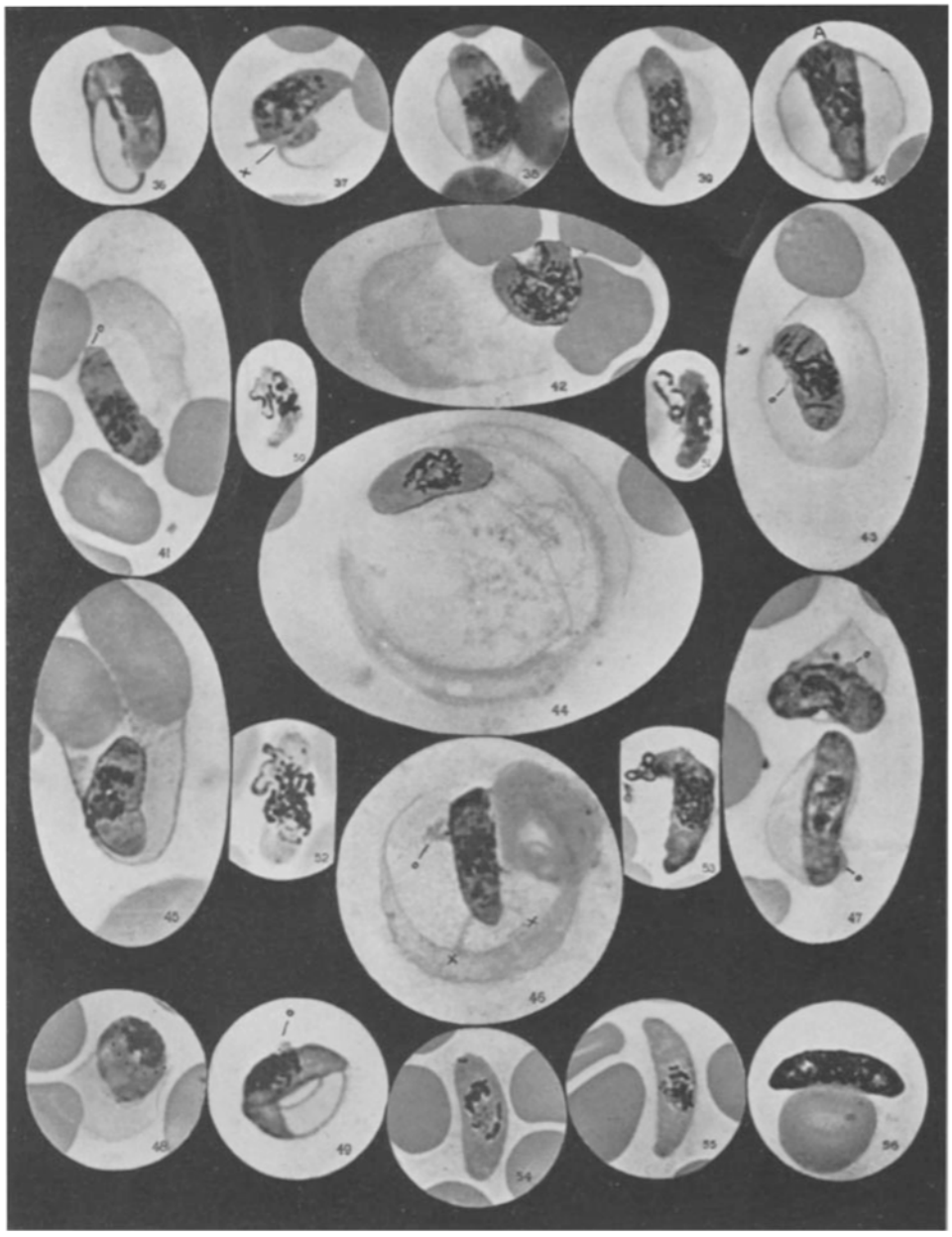
FIGS. 50 to 53. Flagellated crescents. With the exception of Fig. 53, which is attached to a decolorized corpuscle, these crescents are free from corpuscles. They are healthy appearing and the presence of pigment is evidence of previous attachments. The flagella arise from the chromatin substance of the parasites.

FIGS. 54 and 55. Free pigmented crescents.

FIG. 56. A very heavily pigmented crescent which, I believe, is in the process of attaching itself to a fresh corpuscle, as the red corpuscle shows no evidence of injury to its hemoglobin. A careful examination of this figure will show the hemoglobin of the red corpuscle extending into the substance of the crescent. The large amount of pigment which the parasite contains is evidence of previous attachments.



(Lawson: Æstivo-autumnal malaria.)



(Lawson: Æstivo-autumnal malaria.)