Blood Parasites of Mammals in New Zealand*

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CONTENTS

This contribution forms part of an investigation undertaken during the tenure of a New Zealand University Research Fund Fellowship.

SUMMARY

The morphology of *Trypanosoma lewisi* (Kent) from introduced rats in New Zealand is compared with that of the same flagellate from rats in England; and *Hepatozoon musculi* (Porter) is recorded from mice, *Mus musculus* Linnaeus, the locality record for the latter parasite being new. The post-mortem invasion of the blood of rabbits, *Oryctolagus cuniculus* (Linnaeus), by yeast-like vegetable cells of intestinal origin is discussed, and the possibility suggested that the organism concerned may be identical with that described by Sangiorgi as *Hepatozoon cuniculi*. *Anaplasma*-like bodies are recorded from cattle and from the Australian grey opossum, *Trichosurus vulpecula* (Kerr).

INTRODUCTION

Little attention has been paid to the study of mammalian haematozoa in New Zealand. Apart from Doré's (1918) record of *Trypanosoma lewisi* (Kent) from rats in various parts of the North Island, the only references to mammalian blood parasites in this country are those of Gilruth (1909), who recorded *Anaplasma*-like bodies both free in the plasma and within the red corpuscles of pigs, and of Reakes (1913), who noted an infection of (*Microfilaria*) = *Dirofilaria immitis* in a dog quarantined at Auckland.

The results of the examination of blood smears from 494 mammals of 15 species (13 introduced and 2 indigenous) during the period 1947–49 are detailed in the following pages.

MATERIAL AND METHODS

Heart-blood smears of domestic animals were made at abattoirs, while preparations from pest species were made with the co-operation of Government and local-body eradication agencies. No material was obtained from either of our two species of bats, the only land mammals native to New Zealand. Peripheral-blood smears from two examples of the fur seal *Arctocephalus forsteri* were obtained by pricking a flipper with the point of a scalpel, while material from the humpback whale *Megaptera nodosa* was collected at the Tory Channel whaling station.

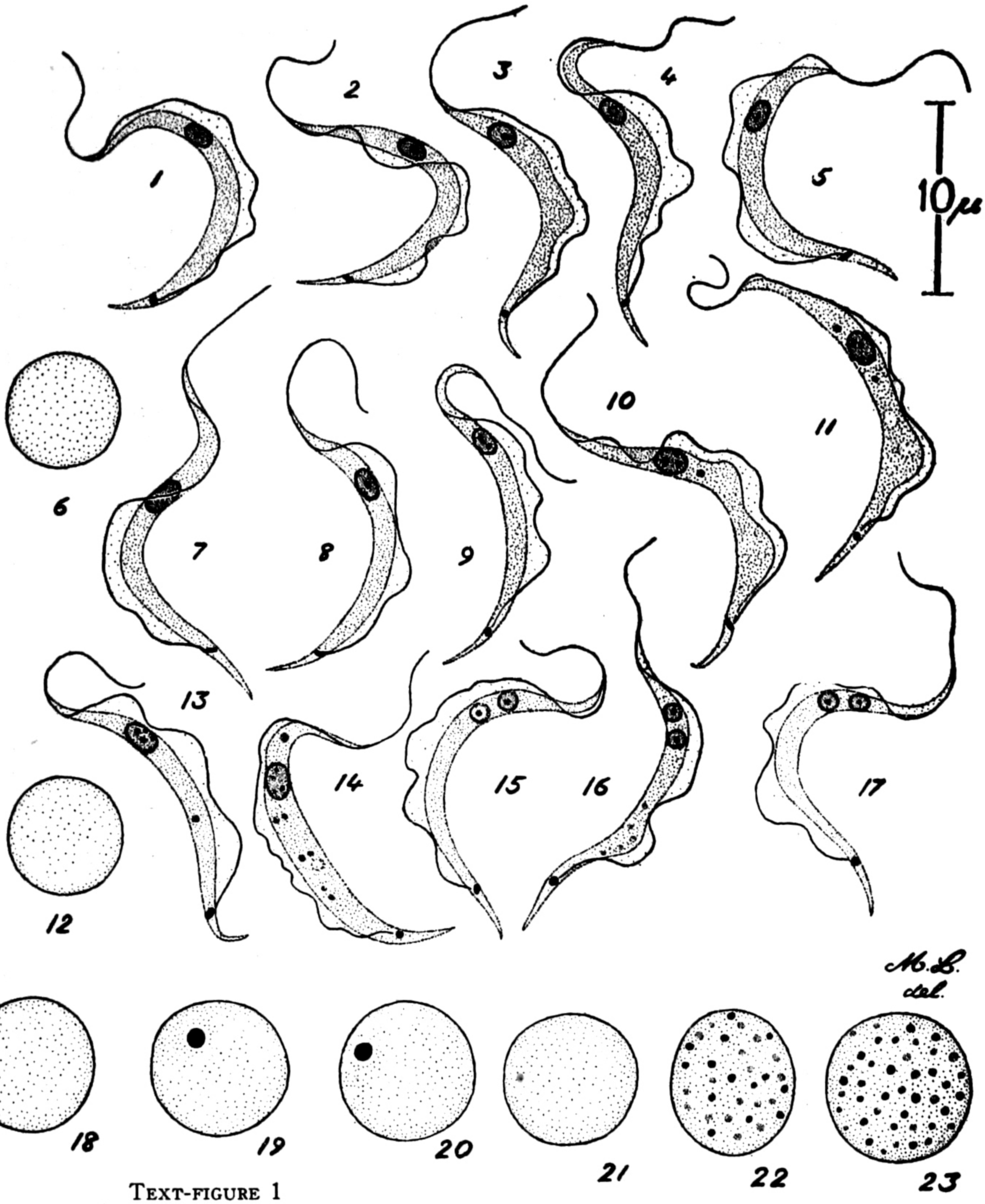
Thin blood and organ smears were made on 3 in. x 1 in. microscopic slides, air dried, fixed in absolute methyl alcohol, and stained with Giemsa. The uncovered smears were studied under a x5 ocular and a x97 oil-immersion objective, each slide being examined for at least half an hour. All figures were drawn with the aid of an Abbé camera lucida at a magnification of 2,400, a x15 ocular being substituted for the x5 used in searching.

Trypanosoma lewisi (Kent, 1880)

(Text-figure 1, Figs. 1–17)

Doré (1918) was the first to record *Trypanosoma lewisi* from New Zealand, stating that this flagellate was first found in rats from the Auckland area in 1912. Of "several hundred" rats from various parts of the North Island examined by Doré, 30 per cent. of those captured in the neighbourhood of sewers and 12 per cent. of those from wharves and grain stores were infected. *T. lewisi* is widespread in Australia (Pound, 1905; Johnston, 1909), where Bancroft recorded it as *Haematomonas* as early as 1888.

Sixty-five specimens of *Rattus norvegicus* (Erxleben) obtained from buildings in Wellington were examined for haematozoa during 1947 and 1948. Three of these proved to be parasitized by *Trypanosoma lewisi*, two being lightly infected and one very heavily infected, with an average of one trypanosome to every eight host erythrocytes. Doré mentions that one of the infected rats which he handled had one trypanosome to every four of its erythrocytes.



TEXT-FIGURE 1

Figs. 1–5, 7–11, 13–17: *Trypanosoma lewisi* (Kent, 1880), from *Rattus norvegicus* (Erxleben). Figs. 6 and 12: Erythrocytes of *R.. norvegicus.* Fig. 18: Normal erythrocyte of *Trichosurus vulpecula* (Kerr). Figs. 19 and 20: *Anaplasma*-like bodies from *T. vulpecula.* Fig. 21: Normal erythrocyte of *Bos taurus* Linnaeus. Figs. 22–24: Basophilic granulation in erythrocytes of *B. taurus.* Figs. 25 and 26: *Anaplasma*-like bodies from *B. taurus.*

1 2 3 4 5

10μ

6 7 8 9 10 11

13 14 15 16 17

12

M.L. del.

18 19 20 21 22 23

24 25 26

Trypanosoma lewisi is of long slender form, both extremities of the body tapering to a fine point. As Minchin (1909) points out, it usually appears C-shaped (Figs. 1 and 2) or S-shaped (Fig. 4) in permanent preparations. The prominent undulating membrane very rarely (Fig. 2) appears at the concavities of the curves. It usually keeps to the convex side, crossing over the body at each curve (Figs. 4 and 6), as described by Minchin. The nucleus is of oval shape, its long axis being in line with that of the body. The alveolar cytoplasm stains light blue with Giemsa. Both the nuclear membrane and the small central karyosome stain deep red, and the space between them lighter red. The flagellum varies in apparent thickness according to the degree of extraction of the stain. It originates from a blepharoplast which lies immediately anterior to the parabasal body but which cannot always be differentiated from the latter structure in Giemsa-stained material. The kinetoplast as a whole stains bright pink, and appears circular (Figs. 3, etc.) to rod-shaped (Figs. 5, etc.).

The average dimensions of 100 examples of *T. lewisi* from my material are given below, the figures in parentheses being those given in or determined from Minchin's (1909) account of this flagellate.

Length of free flagellum	7.1μ	(6.9μ)
Length of body	22.9μ	(23.7μ)
Total length	30.0μ	(30.6μ)
Width of body at centre of nucleus	1.1μ	(—)
Length of nucleus	1.7μ	(—)
Width of nucleus	1.1μ	(—)
Width of undulating membrane	1.0μ	(—)

The length of the free flagellum averages 31.0 per cent. (29.1 per cent.) of that of the body. In most cases the nucleus occupies the full width of the body, and is situated 30.0 per cent. (29.6 per cent.) of the body length from the root of the free flagellum. The parabasal body is located 15.1 per cent. (18.9 per cent.) of the body length from the posterior extremity.

It will be seen that there are slight differences between Minchin's figures and mine. This may be because the trypanosomes concerned belong to different strains, or may be due to the fact that Minchin's figures are based on the measurement of only ten examples of *T. lewisi*.

Some of the larger examples of *T. lewisi* in my material have from one to many extranuclear chromatin granules in the cytoplasm (Figs. 10–14). The nuclei of such forms frequently contain several densely staining granules of similar nature, and the cytoplasm often has large vacuoles (Fig. 11) and an irregular border on the convex side (Figs. 10 and 11). It is likely that such trypanosomes are degenerative forms which are undergoing necrosis.

Numerous trypanosomes having two nuclei occur in material from the heavy infection mentioned above (Figs. 15–17). The nuclei, unlike those of normal examples of *T. lewisi*, are of circular shape. They average 1.0μ in diameter, and occur close together in the usual situation of the normal single nucleus. Trypanosomes with two nuclei show no other signs of division. It is probable that as Minchin (1909) suggests, they are abnormal forms, having nothing whatever to do with division.

T. lewisi is transmitted from rat to rat by the flea *Ceratophyllus fasciatus*, which is a common ectoparasite of *Rattus norvegicus* in New Zealand. Rats become parasitized by eating infective fleas or the faeces of such fleas (Wenyon, 1926).

Hepatozoon musculi (Porter, 1908)

(Plate 1, Figs. 1–10)

Miller (1908) established the genus *Hepatozoon* for an intraleucocytic parasite pathogenic for white rats which he named *Hepatozoon perniciosum,* a name which has since fallen as a synonym of *Hepatozoon muris* (Balfour). Members of the genus described at an earlier date had been considered to belong to *Haemogregarina* or *Leucocytozoon,* and the priority of *Hepatozoon* was not generally accepted for many years. Porter (1908) described as *Leucocytozoon musculi* a white cell parasite which she discovered in the blood of white mice in England. A year later Porter (1909) wrote: " . . . the structure and life history of avian *Leucocytozoa* are still subjects of controversy, and as the name *Leucocytozoon* was first applied to parasites of birds . . . the generic name *Leucocytogregarina* might be used for the highly specialized parasites of mamalian leucocytes, which have a different habitat from the strict Haemogregarines of red corpuscles." Sangiorgi (1912), in recording *Leucocytogregarina musculi* from Turin, was the first to use the name *Leucocytogregarina* in a generic sense, as Wenyon (1926) points out. Coles (1914) considered a parasite found free in the plasma of *Mus sylvaticus* to be closely allied to that described by Porter from *Mus musculus,* but suggested the name *Haemogregarina sylvatici* for his parasite in the event of its proving to be a new species. Yakimoff and Schokhor (1917) recorded *Leucocytogregarina musculi* from Petrograd (Leningrad), and Porter (1919) herself used *Leucocytogregarina* as the generic name of the mammalian haemogregarines. Wenyon (1926) finally established the priority of Miller's generic name *Hepatozoon* for these parasites.

Hepatozoon musculi has not previously been recorded from Australasia, although, as it probably transmitted through the agency of an ectoparasitic mite or louse (Porter, 1908; Sangiorgi, 1912), it is to be expected that its range will be found to correspond with that of its cosmopolitan host (c.f. *Trypanosoma lewisi). Hepatozoon muris* (Balfour), recorded from West Australia (Cleland, 1906) and New South Wales (Johnston and Cleland, 1909), has not yet been found in New Zealand.*

A moderately heavy infection of *H. musculi* is recorded from a specimen of *Mus musculus* Linnaeus trapped in Wellington during March, 1948. Thirty-seven other mice examined during the survey were negative for haematozoa. The infected mouse had been dead for some twelve hours when a heart-blood smear was made. All but one of the parasites (Plate 1, Fig. 10) on the smear were free in the plasma. This is probably due to the fact that intraleucocytic forms had become free at some stage between the death of the host and the drying of the smear. *Hepatozoon* infections are usually characterized by a predominance of intraleucocytic parasites. Thus Yakimoff and Schokhor (1917) failed to find any free forms of *H. musculi,* while Porter (1908) and Sangiorgi (1912) found a predominance of intraleucocytic forms in fresh material. Coles (1914), who found only free forms of *Hepatozoon* in his preparations from *Mus sylvaticus,* failed to state how fresh his material was.

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*Since this paper went to press, *H. muris* has been recorded from *Rattus norvegicus* in Raoul Island, Kermadec Group—Laird, M., 1950. A New Locality for Two Blood Parasites of Rats (Raoul Island, Kermadec Group). *N.Z.Sci.Rev.,* 8 (9–10), 91–92.

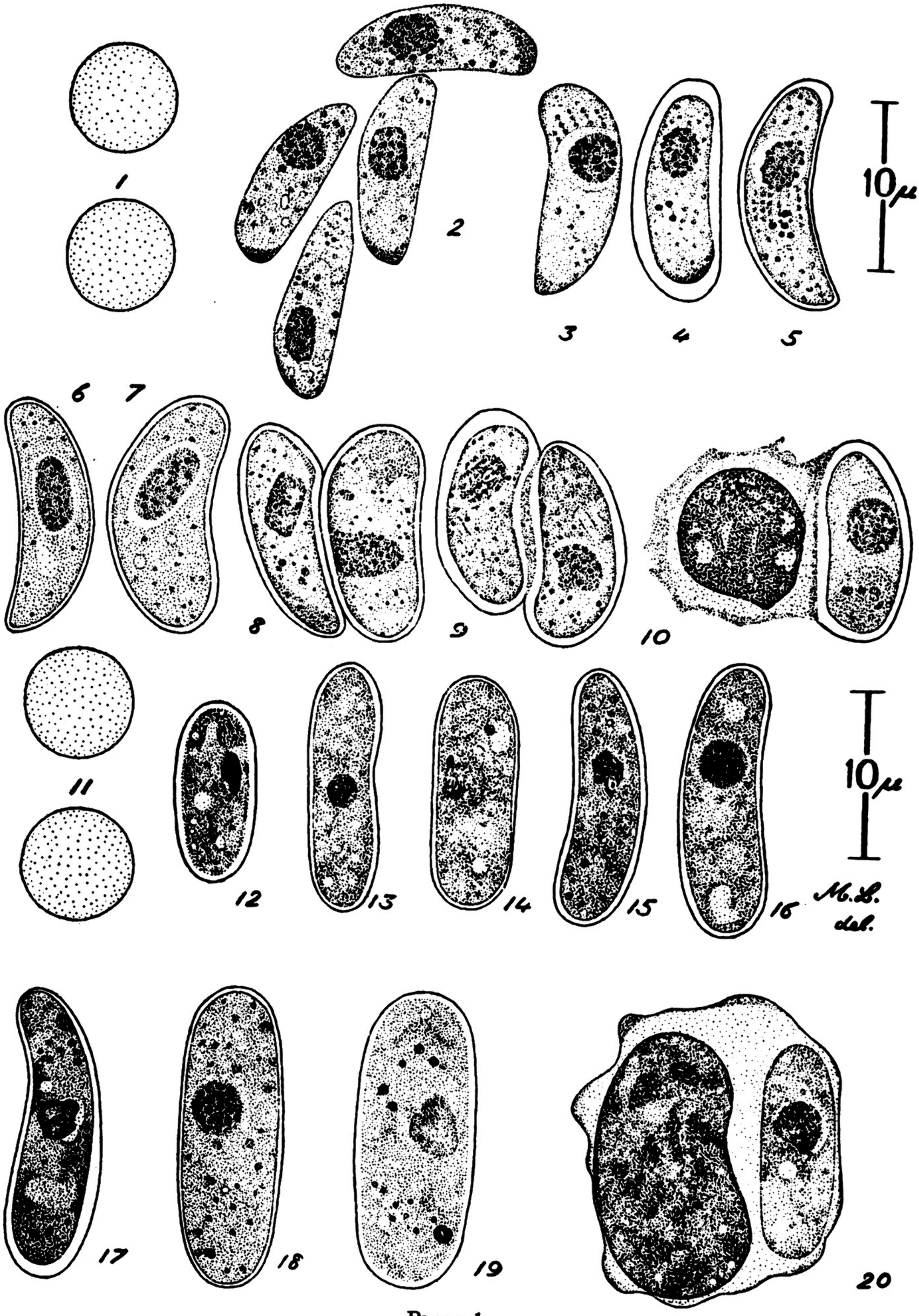
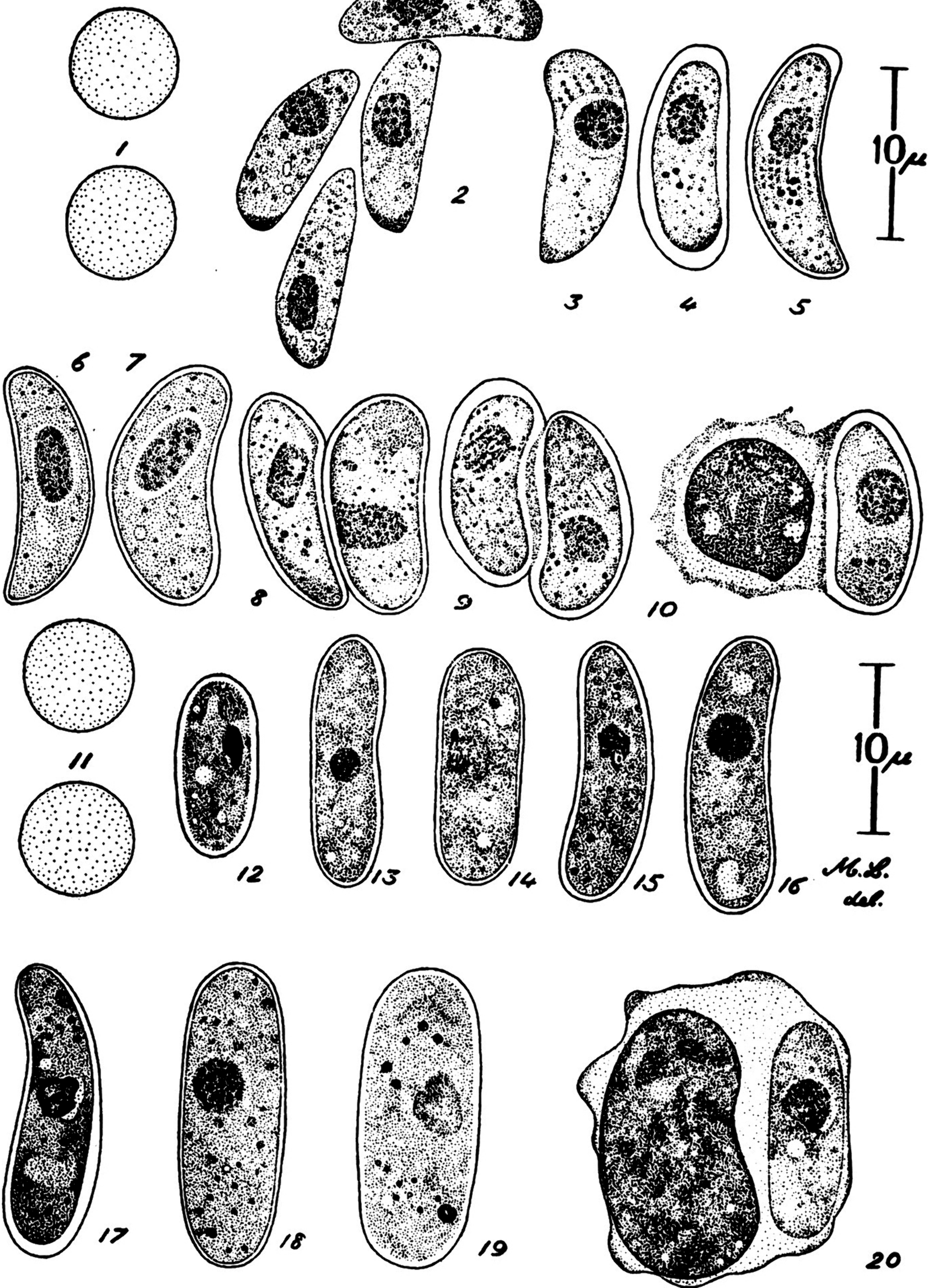


PLATE 1

Fig. 1: Erythrocytes of *Mus musculus* Linnaeus. Figs. 2–10: *Hepatozoon musculi* (Porter, 1908), from *M. musculus*. Fig. 11: Erythrocytes of *Oryctolagus cuniculus* (Linnaeus). Figs. 12–20: Yeast-like organisms resembling *Hepatozoon cuniculi* (Sangiorgi, 1914), from *O. cuniculus*.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My average measurements for the free forms of *H. musculi* are 11.3μ by 4.0μ, while the size range is 10.6μ to 14.8μ by 3.8μ to 6.3μ. These figures compare favourably with those of Porter (1908), 10.9μ by 5.1μ (range 7.0μ to 17.0μ by 4.0μ to 5.9μ). Sangiorgi (1912) gives no averages, but his size range compares well with mine, 9.4μ to 14.2μ by 3.8μ to 6.3μ. Coles (1914) gives an average only, his figures of 15.5μ by 6.1μ coming towards the higher level of the size range of other investigators.

Free forms of *H. musculi* are reniform to crescentic bodies which occur in my material both with capsules (Plate 1, Figs. 4–9) and without them (Plate 1, Figs. 2 and 3). The ends are usually rounded, sometimes almost equally so (Plate 1, Figs. 4 and 7), but more frequently one end is markedly more pointed than the other (Plate 1, Figs. 3, 5, etc.). The close association of the members of the group of four parasites without capsules illustrated in Plate 1, Fig. 2, in a smear where three or four minutes' search was usually required for the discovery of a single parasite, points to their being recent products of schizogony. Non-encapsuled free forms are probably merozoites. These invade leucocytes of the host, and during the intracellular stage (Plate 1, Fig. 10) the capsule is developed. According to Porter (1908), intraleucocytic stages of *H. musculi* have average measurements of 8.0μ by 5.0μ, while Yakimoff and Schokhor (1917) give the size range as 8.0μ to 10.0μ by 4.0μ to 5.0μ. The single example on my slide measures 10.8μ by 4.4μ. Free, encapsuled forms are fully developed gametocytes.

In all stages of *H. musculi* encountered in my material, the finely vacuolated cytoplasm stains light blue with Giemsa. The cytoplasm is often markedly granular, and the small granules, which are particularly evident along the course of the myonemes (Plate 1, Figs. 3 and 5), take a deep blue stain and at times (Plate 1, Figs. 8 and 9) appear almost black. The nucleus is generally situated towards one end of the body, but it may be approximately central. This structure, which may be circular, oval, band-like, or irregular in shape—as will be seen from the figures—assumes a deep pink stain, its chromatin being aggregated into dense granules staining deep red. A prominent terminal cap of chromatic material may be present at one (Plate 1, Figs. 2–4, 8–10) or occasionally both extremities, as stated by Porter (1908). From five to seven myonemes (Plate 1, Figs. 3 and 5) may be traced in suitably stained parasites (Coles, 1914, mentions six or seven). As Coles also observes, the myonemes may give the nucleus a longitudinally segmented appearance (left-hand parasite, Plate 1, Fig. 9).

Broad (Plate 1, Fig. 7) and slender (Plate 1, Figs. 4–6) gametocytes may be distinguished, but it is doubtful whether there is any real sexual dimorphism. Such a hypothesis is favoured by the occurrence of cases of association between large and small gametocytes (Plate 1, Fig. 8), but there is by no means always a significant difference in the sizes of the gametocytes concerned. Porter (1908) and Sangiorgi (1912) also record and figure such association between the gametocytes of *H. musculi*. The process is possibly an artefact as seen in preparations of vertebrate blood. By analogy with the behaviour of *H. muris* in the gut of the mite *Laelaps echidninus*, noted by Miller (1908), such association between gametocytes in vertebrate blood cooling after the death of the host probably represents the commencement of the process leading to fertilization and zygote formation which normally takes place in the gut of the invertebrate host.

It should be emphasized that on purely morphological grounds the parasite in my *Mus musculus* material fits available descriptions of *Hepatozoon muris* quite as well as it does those of *H. musculi*. The authenticity of many of the described species of *Hepatozoon* is questioned by Porter (1919) and Wenyon (1926), the former suggesting " . . . it is quite likely that the various leucocytogregarines now given separate specific names . . . are really only varieties of the first described species, *L. canis* (James, 1905)," while Wenyon postulates that *Hepatozoon musculi* and *H. muris* may well be one and the same species. Nevertheless, many mammalian blood parasites exhibit a close host specificity, and this fact necessitates the exercise of caution in determining their specific identity. At the same time, by analogy with the facts that *H. muris* occurs in several species of the genus *Rattus*, and that *Trypanosoma lewisi* and *T. duttoni* occur in more than one species of *Rattus* and *Mus* respectively, it seems unnecessary to regard the parasite recorded by Coles (1914) from *Mus sylvaticus* as distinct from *Hepatozoon musculi* on grounds of host specificity alone.

Artefact resembling *Hepatozoon cuniculi* (Sangiorgi, 1914)

(Plate 1, Figs. 11–20)

Smears of the heart blood and organs of 21 of 48 specimens of the introduced rabbit, *Oryctolagus cuniculus* (Linnaeus), mostly collected in the Wairarapa area during 1947–49, were found to contain numerous examples of an organism which was at first taken to be a *Hepatozoon*. All the preparations were made within an hour or two of the death of the host, by an investigator primarily concerned with ectoparasites and intestinal protozoa and helminths. Peripheral-blood smears made from the vessels of the ear of rabbits kept alive in the laboratory after their capture proved uniformly negative for the organism, although heart-blood and organ smears made after the death of these same animals were heavily positive.

Patton (1908) recorded *Leucocytozoon leporis* as a new species of leucocytic haemogregarine from the Indian black-naped hare (*Lepus nigricollis*), but failed to publish a description. Sangiorgi (1914) described *Leucocytogregarina cuniculi* from the domestic rabbit in Italy. According to Porter (1919), who records *Leucocytogregarina leporis* (Patton) from South African rabbits, there is evidence that asexual multiplication of this parasite takes place in the lungs.

As there is considerable difficulty in obtaining Sangiorgi's account of *Hepatozoon cuniculi* today, and as no English translation has been published, an abbreviated translation is given below.

The cytoplasm of (*Leucocytogregarina*) = *Hepatozoon cuniculi* is finely and uniformly granular, and stains very light azure blue with Giemsa. The body of the parasite is elongate, slightly concave on one side and rounded at the extremities, which are not always perfectly symmetrical. Small masses of chromatic material are often present at the wider extremity. The nucleus, which is generally situated towards the narrower extremity, is of oval shape and contains chromatic masses interspersed with achromatic zones as does that of *H. musculi*. A fine and very regular clear space about the body corresponds with the capsule, and is very resistant to staining. The average measurements of the characteristic forms from splenic smears are 16.6μ to 18.2μ by 4.1μ to 4.9μ. Other, less common, forms reach the same average length but are more slender, being only 3.5μ in width. Still others are stout, measuring some 14.0μ by 6.6μ and having more rounded extremities and being more symmetrical than those first described. The nucleus of the stout form

is compact and perfectly median (and appears from Sangiorgi's Fig. 2 to be of irregular shape). Smaller forms morphologically similar to that just described but measuring 12.5μ by 3.5μ are sometimes found in the cytoplasm of large mononuclear leucocytes. No multiplication stages have been found in preparations of the blood or organs, perhaps because the infection studied was an early one (Sangiorgi, 1914).

The organism in my material from *Oryctolagus cuniculus* (Plate 1, Figs. 12–20) corresponds so closely with that described by Sangiorgi as *Hepatozoon cuniculi* that it was at first identified with this species. It has granular cytoplasm resembling that of *H. cuniculi,* and assuming a light blue colour in suitably stained smears. A varying number of vacuoles may be present in the cytoplasm, which sometimes shows maculation (Plate 1, Fig. 17). The body of the common form resembles that of the equivalent form of *H. cuniculi* in being elongate with one side slightly concave (Plate 1, Figs. 13, 15–17), and in having rounded extremities, one of which is usually narrower than the other. The size range of this form is 15.0μ to 18.0μ by 4.0μ to 5.0μ, which compares closely with the 16.6μ to 18.2μ by 4.1μ to 4.9μ of *H. cuniculi.* In most cases the nucleus, which is situated either centrally or somewhat towards the narrower end of the body, stains densely and uniformly pink. It may be round (Plate 1, Figs. 13 and 16) or irregular (Plate 1, Figs. 14, 15, 17) in shape. Oval organisms are rarer, and these range in size from 10.8μ to 18.0μ by 4.9μ to 7.2μ. They compare well with the stout form of *H. cuniculi,* and usually have a dense and irregular nucleus not quite central in position (Plate 1, Figs. 12, 14, 19). One lightly stained example has a round nucleus stained light pink with deeper pink chromatic masses (Plate 1, Fig. 18). All forms so far described are surrounded by a capsule which, like that of *H. cuniculi,* takes up no stain and appears as a sharply defined halo surrounding the body. Some of the large oval examples (Plate 1, Fig. 19) have a faintly staining nucleus and numerous round extranuclear chromatic granules. These granules range in size from dot-like particles to bodies 1.2μ in diameter. They stain an intense blackish-red, and are indicative of pyknosis. A single intraleucocytic organism has been observed (Plate 1, Fig. 20). This has no capsule, and is within the cytoplasm of a large mononuclear leucocyte.

The dominant irregular shape of the nucleus and the usual uniformly dense staining reaction of this structure, coupled with the fact that with Giemsa the cytoplasm frequently assumes an intensely blue colour quite unlike that characteristically taken by the haemogregarines, raised some doubts in my mind concerning the systematic position of the organism from *Oryctolagus cuniculus.* These doubts were unexpectedly confirmed on perusal of an account of supposed blood parasites by Wenyon (1923), who actually described how the appearance of a haemogregarine infection may be produced by allowing a film of water containing large "bacilli" from the faeces of rabbits to dry on a slide, after which a blood film is prepared on the slide and stained with Leishman. The examples of vegetable cells figured by Wenyon (1923) from such an intentionally contaminated preparation (his Fig. 10) bear a striking resemblance to the organisms from my material from *Oryctolagus cuniculus.* Accordingly, smears were prepared from the faeces of rabbits which had proved positive for the *Hepatozoon*-like organism at autopsy. The smears, after staining with Giemsa, were found to contain very large numbers of cells (Plate 1, Figs. 12, 15, 16) similar in every respect to those from the blood and organs, which are thus identified as yeast-like vegetable cells of intestinal

origin. The granules referred to above as indicative of pyknosis are probably volutin granules, which are often abundant in yeasts (Henrici, 1941).

Wenyon had probably not studied Sangiorgi's description of *Hepatozoon cuniculi* at the time of writing his paper. Otherwise he would surely have been impressed by the close resemblances between *H. cuniculi* and the organism from the alimentary tract of the rabbit, for he himself said of his experiment that it "will convince anyone of the difficulty there would be of distinguishing such organisms from Protozoa if they occurred unexpectedly in blood films. It is hardly necessary to emphasize the resemblance they have to some of the 'haemogregarines' described."

Smears of the blood and organs of freshly killed rabbits have been made under sterile conditions. As careful search has failed to reveal the presence of yeast-like cells in the peripheral blood of living specimens of *Oryctolagus cuniculus*, it thus seems likely that these cells invade the blood stream from the intestine soon after death. The intracellular form illustrated in Fig. 20 is explained as an organism which has been ingested by a large mononuclear leucocyte.

I consider the resemblances between the organism described as *Hepatozoon cuniculi* (Sangiorgi, 1914) and the yeast-like cells from *Oryctolagus cuniculus* to be strong enough to warrant "*H. cuniculi*" being regarded as an artefact of vegetable nature, unless definite evidence of its protozoan nature can be obtained.

STRUCTURE OF UNCERTAIN NATURE

Anaplasma, Theiler, 1910

(Text-figure 1, Figs. 18–26)

Theiler (1910) established the genus *Anaplasma* for intraerythrocytic bodies which he considered to be the causal organisms of gall-sickness in African cattle. *Anaplasma* may occur either free in the plasma or within red cells. The bodies are of irregularly circular shape and range up to 2μ in diameter. With Giemsa they stain deeply and uniformly red and appear quite devoid of internal structure. Intraerythrocytic anaplasmata are usually marked off from the host cell cytoplasm by a lightly staining halo. Theiler considered *Anaplasma* to be a protozoon consisting entirely of chromatin, but its protozoan or even parasitic nature has yet to be demonstrated. A few years after the publication of Theiler's account of *Anaplasma*, similar bodies had been recorded from all the great vertebrate groups (Porter, 1915). It is difficult to differentiate between *Anaplasma* and Jolly bodies, if, indeed, there is any actual distinction between these structures. Jolly bodies are spherical, stain deep red with Giemsa, and have a similar size range to that of *Anaplasma*. They occur in the blood of young and anaemic animals, and, according to Wenyon (1926), are generally supposed to represent the remains of the nuclei of immature red cells. Wenyon suggested that *Anaplasma* may have the same origin as Jolly bodies, becoming associated with disease conditions in cattle as a secondary result of infection with some as yet unknown virus.

Gilruth (1909) recorded structures free in the plasma and within the red cells of pigs in New Zealand. He subsequently (Gilruth *et al.*, 1911) recognized these as *Anaplasma*. During the present survey *Anaplasma*-like bodies were seen in smears from a majority of the species of all classes of vertebrates examined. Bodies of this kind from grey opossums and cattle are described below.

Heart-blood smears of 71 specimens of the Australian grey opossum *Trichosurus vulpecula*, trapped in the Orongorongo ranges during April and May, 1947, were

searched for haematozoa. No such parasites were found, but in every smear at least a few erythrocytes were found to contain *Anaplasma*-like bodies (Text-fig. 1, Fogs. 19 and 20). The bodies occur within the erythrocytes both singly and in diplococcus-like pairs, and are also found free in the plasma. They stain deeply and uniformly red with Giemsa, are often surrounded by a distinct halo, and range in diameter from 0.9μ to 1.8μ Most of the bodies occur at or near the margin of the host cell, thus resembling *Anaplasma marginale* Theiler, 1910, also the similar bodies described from *Trichosurus vulpecula* in Australia by Gilruth *et al.* (1911).

Bodies similar to the above in every respect were seen in the blood of 36 cows examined at the Wellington City Corporation Abattoirs during October, 1947 (Text-fig. 1, Figs. 25 and 26). In most cases only a few cells of each smear contain *Anaplasma*-like bodies, although in one preparation a considerable proportion of the erythrocytes are involved. Numerous cells of the latter smear show pronounced basophilic granulation (Text-fig. 1, Figs. 22–24) like that described by Johnston and Cleland (1909) from the blood of two cows suffering from endemic haematuria of vesicle origin. From 30 to 45 purplish staining granules of varying size (Plehn's bodies) occur in each corpuscle, the cells concerned being larger than normal erythrocytes and polychromatophilic like those studied by Johnston and Cleland.

These granules bear a marked resemblance to the bodies described as *Grahamella* by Brumpt (1911), from which, however, they differ in being of rounded shape, *Grahamella* usually appearing as short straight or curved rods. Red cells containing basophilic granules occur commonly in bone marrow, and those under discussion in all probability owe their appearance in the peripheral blood to an anaemic condition.

TABLE 1

A list of the mammals examined from which no haematozoa were recorded (an asterisk * denotes a non-indigenous species).

Systematic position	Common name	No. examined	Locality	Month and year
Phalangeridae				
**Trichosurus vulpecula* (Kerr)	Grey opossum	71	Orongorongo	4–5/47
Macropodidae				
**Wallabia ualabatus* (Lesson & Garnier)	Black-tailed wallaby	50	Waimate	7/47
Erinaceidae				
**Erinaceus europaeus* Linnaeus	Hedgehog	6	Wellington	11/48
Leporidae				
**Oryctolagus cuniculus* (Linnaeus)	Rabbit	48	Various North Island localities	47–49
Mustelidae				
**Putorius putorius* (Linnaeus)	Polecat	1	Canterbury	7/47
**Mustela erminea* Linnaeus	Stoat	1	Fiordland	2/49
Felidae				
**Felis domestica* Brisson	Cat	9	Wellington	6/48
Otariidae				
Arctocephalus forsteri (Lesson)	Fur seal	2	Kapiti Island	8/47
			Wellington	5/48
Balaenopteridae				
Megaptera nodosa (Bonaterre)	Humpback whale	15	Cook Strait	7–8/48–49
Cervidae				
**Cervus elephas* Linnaeus	Red deer	8	Tararua Mtns.	4/47
Bovidae				
**Bos taurus* Linnaeus	Cattle	36	Wellington	10/47
**Capra aegagrus* Erxleben	Goat	7	Wellington	5/48
**Ovis aries* Linnaeus	Sheep	137	Wellington	10/47

DISCUSSION

No haematozoa have yet been recorded from any of the mammals indigenous to New Zealand. The few smears from seals and whales examined during this study all proved negative for haematozoa, which is not surprising in view of the fact that no blood parasites have yet been recorded from any of the marine mammals. As already mentioned, no examples of either of our two rare species of native bats could be obtained for study. The examination of blood smears from these animals would be of the highest interest in view of the primitive status of the short-tailed bat *Mystacops tuberculatus*, and because of the occurrence of *Plasmodium*, *Trypanosoma*, and other haematozoa in many species of Chiroptera in other parts of the world.

Trypanosoma lewisi was first recorded from the cosmopolitan *Rattus norvegicus* in New Zealand by Doré (1918). This author suggested that the rapid decline in numbers of the Polynesian rat (*Rattus exulans*) might be due to infection with *T. lewisi*. As the Polynesian rat is now very rare, the opportunity of testing this hypothesis has not yet arisen. Both *T. lewisi* and *Hepatozoon muris* are known from rats in Australia (Pound, 1905; Cleland, 1906; Johnston, 1909; etc.), there being no record of the latter parasite from New Zealand. Conversely, *Hepatozoon musculi*, here recorded for the first time from *Mus musculus* in New Zealand, is not known from Australia.

Trypanosoma melophagium has not yet been found in the blood of sheep in New Zealand, although 137 thin blood smears collected from these animals at the Wellington abattoirs have been studied. In Europe and England this parasite is widely distributed (Hoare, 1923), but infections are so slight that culture techniques usually have to be employed before its presence is revealed. Hoare found at least 80 per cent. of an infected flock to be parasitized by using culture techniques, although some 300 blood smears from the same flock proved uniformly negative for *T. melophagium*. The sheep-ked *Melophagus ovinus*, an obligatory ectoparasite of sheep, is the only known invertebrate host of this trypanosome (Hoare, 1923), and the incidence of *Trypanosoma melophagium* in a given area closely parallels that of the sheep-ked. As *Melophagus ovinus* occurs in New Zealand, it would thus be premature to state that *T. melophagium* is absent from this country before a much more extensive survey, involving the use of culture techniques, has been carried out. The examination of negative material from 48 rabbits and 36 cattle likewise gives no grounds for assuming that the trypanosomes which parasitize these animals in Europe are absent from New Zealand.

Although *Dirofilaria immitis* (Leidy) has been reported from New Zealand (Reakes, 1913), the species, the causal agent of canine filariasis, is not established in this country. The case recorded by Reakes concerns a dog landed in New Zealand in the course of Captain Scott's last expedition to Antarctica. Microfilarial embryos were found in the blood of this dog when it was quarantined, and the animal was subsequently destroyed. It is of interest that a number of Scott's sledge dogs died in Antarctica as a result of infestation with *Dirofilaria immitis*. Atkinson (in Cherry–Garrard, 1948, p. 454) considered that the probable place of infection was Vladivostock, from which port the dogs were shipped to New Zealand on their way southwards. *Dirofilaria immitis* is well established in Australia and many of the Pacific Islands, notably Fiji, and it is of the greatest importance that quarantine measures directed against the importation of this nematode into New Zealand should at all times be stringently enforced.

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