by the recent contributions of Vincent and Sheen⁴¹ and others. If high pressure can result from default of depressor substances the failure of the search for separate pressor agents in the blood might conceivably be accounted for.

A tissue extract that has recently been the subject of active investigation is liver extract, which has been found to have pronounced depressor effects, studied by various observers. As prepared by James, Laughton, and Macallum,¹⁸ the active extract is stated to be free from the shock-producing substance histamine and from choline. Fresh extract is necessary, and while the experimental effects are marked, the clinical data in high-pressure cases in man are not conclusive. Major reports striking and lasting effects in certain high pressures of recent origin without recognizable lesions, while not overlooking the occurrence of occasional "spontaneous" recoveries in such cases. In "fixed" pressures of long standing there was little evidence of specific effect with the liver extract. Some observers interpret the depressor effects of the liver extracts which they used as being due to histamine and choline (Best, Dale, Dudley, and Thorpe⁶).

Conclusion.

From the foregoing considerations it is evident that while the incidence of the disturbing agency on the medullary regulating centres is clearly indicated, precise and adequate knowledge of the causation and mechanism of high pressures is defective. The fact of high pressures coming under observation in man only, and the consequent inapplicability of many of the methods of experimental research, have to be borne in mind as limiting the modes of attack upon the problem. While it is obvious that much more knowledge is necessary for the definite solution of the question involved, it has seemed advisable to take stock of the present situation as it appears to a physiologist, in order to avoid the waste of laborious work in accumulating data such as are already available. It is necessary to keep an open mind as to the possibility of a solution being found in an unexpected direction—in the discovery of a precise causal agent or agencies different from those that are mostly in question at the present time as bearing on the condition of high pressures, which may prove to be multifactorial in causation and mechanism as also in clinical type.

REFERENCES.

- ¹ Allbutt: *Diseases of the Arteries*, London, 1915.
- ² Allbutt: *Arteriosclerosis*, London, 1925.
- ³ Anderson: *Arch. Int. Med.*, 1925, xxxviii, 297.
- ⁴ Anrep and Starling: *Proc. Roy. Soc.*, 1925, B, xcvi, 463.
- ⁵ Batty Shaw: *Hyperpiesia and Hyperpiesia*, London, 1922.
- ⁶ Best, Dale, Dudley, and Thorpe: *Communication to Physiol. Soc.*, March, 1926.
- ⁷ Blume: *Ugeskrift for Laeger*, Copenhagen, 1922, lxxxiv, 1126.
- ⁸ Boas and Frant: *Arch. Int. Med.*, 1922, xxx, 40.
- ⁹ Bordley and Baker: *Bull. Johns Hopkins Univ.*, 1926, xxxviii, 320.
- ¹⁰ Brooks and Carroll: *Arch. Int. Med.*, August 15th, 1912.
- ¹¹ Cash: *Proc. Soc. Exper. Biol. and Med.*, 1926, xxiii, 609.
- ¹² Daly and Verney: *Journ. Physiol.*, 1926, lxi, 268.
- ¹³ Eyster and Hooker: *Amer. Journ. Physiol.*, 1908, xxi, 273.
- ¹⁴ Gruber, Shackelford, and Ecklund: *Arch. Int. Med.*, 1925, xxvi, 366.
- ¹⁵ Hering: *Flüger's Archiv*, 1924, cxxvii, 772.
- ¹⁶ Herringham: *Kidney Diseases*, London, 1912, 219.
- ¹⁷ Janeway: *The Clinical Study of Blood Pressure*, New York and London, 1910.
- ¹⁸ James, Laughton and Macallum: *Science*, lxi, 181; *Journ. Amer. Med. Assoc.*, 1926.
- ¹⁹ Katsch and Pansdorf: *Munch. med. Woch.*, lxi, 1915.
- ²⁰ Krumbhaar: *Journ. Amer. Med. Assoc.*, 1925, lxxxiv, 1691.
- ²¹ MacKenzie: *Proc. Assoc. Life Ass. Med. Dir.*, 1916, vi, 92, 1915, 221.
- ²² MacWilliam: *Quart. Journ. Exper. Physiol.*, 1923, xiii, BRITISH MEDICAL JOURNAL, 1923, ii, 1195; *Physiol. Reviews*, 1925, v, 303.
- ²³ MacWilliam and Melvin: *Heart*, 1914, v, 153; BRITISH MEDICAL JOURNAL, 1914, i, 693.
- ²⁴ Major: *Journ. Amer. Med. Assoc.*, 1926, lxxxvii, 311; *Bull. Johns Hopkins Univ.*, 1925, xxxvi, 357.
- ²⁵ Major and Stephenson: *Bull. Johns Hopkins Univ.*, 1924, 140, 186.
- ²⁶ Mannaberg: *Wien. klin. Woch.*, 1922, xxxv, 145.
- ²⁷ Melvin and Murray: *Quart. Journ. Exper. Physiol.*, 1914-15, viii, 125.
- ²⁸ Mosenthal: *Amer. Journ. Med. Sci.*, 1920, clx, 808; *Med. Clinic. of North America*, 1922, 1189.
- ²⁹ Müller: *Acta Med. Scand.*, 1921, lv, 443.
- ³⁰ Nash: *Proc. Physiol. Soc.*, *Journ. Physiol.*, 1926, lxi.
- ³¹ Nuzum: *Journ. Amer. Med. Assoc.*, 1925, xxxvii, 733.
- ³² Oliver: *Studies in Blood Pressure*, London, 1916.
- ³³ Orr and Innes: *Erit. Journ. Exper. Pathol.*, 1922, iii, 61.
- ³⁴ Reid: *Quart. Journ. Med.*, 1926, xix, 411.
- ³⁵ Rogers and Hunter: *Proc. Assoc. Life Ass. Med. Dir.*, 1921-22, viii, 130; 1919, vi, 92.
- ³⁶ Squier and Newburgh: *Arch. Int. Med.*, 1921, xxviii, 1.
- ³⁷ Starling: BRITISH MEDICAL JOURNAL, 1925, ii.
- ³⁸ Stocks and Karn: *Blood Pressure in Early Life*, London, 1924.
- ³⁹ Strouse and Kelman: *Arch. Int. Med.*, 1923, xxxi, 151.
- ⁴⁰ Symonds: *Journ. Amer. Med. Assoc.*, 1923, lxxx, 232; *Proc. Assoc. Life Ass. Med. Dir.*, 1923, 321.
- ⁴¹ Vincent and Sheen: *Journ. Physiol.*, 1903, xxix, 262; *Lancet*, 1926, i, 1142.

THE INSECT TRANSMISSION OF ONCHOCERCA VOLVULUS (LEUCKART, 1893),

THE CAUSE OF WORM NODULES IN MAN IN AFRICA.*

BY

D. B. BLACKLOCK, M.D., D.P.H.,

PROFESSOR OF TROPICAL DISEASES OF AFRICA, UNIVERSITY OF LIVERPOOL.

AMONG the families of parasitic nematodes which infest man none surpasses in diversity of interest the family Filariidae. This is due both to the pathogenic effects produced by some species, and also to the strange biological adaptations in the human host and in those insect vectors so far known. Complex problems are presented by the larval habits of different species, some living in the blood stream, others having their chief habitat in the skin; some showing the remarkable phenomenon of periodicity, the causes of which are still obscure. No less important are its historical associations; since it was with the species *Filaria bancrofti* of this family that Manson worked when, in 1878, he made the discovery—destined to revolutionize the tropics—of the part played by insects in the transmission of human disease. From this observation dates all that research into the association of insects with disease which has already produced such significant results and which is daily achieving fresh discoveries in the ever-widening domain of human and animal parasitology.

The Genus Onchocerca.

Included in the family Filariidae is the genus *Onchocerca* (Diesing, 1841), which has one species, *O. volvulus*, parasitic in man in Africa, another species, *O. caecutiens*—so closely allied with *O. volvulus* that some authorities consider it identical—parasitic in man in Central America, and several species parasitic in domestic and other animals in various parts of the Old and the New World. Naturally the two species which are parasites of man are of great direct importance. They have a restricted geographical distribution, the ill effects produced by them being confined to the limited regions in which they occur. Of a different order, and affecting man much more widely, are the indirect ill effects produced by those species which infest domestic animals, especially cattle.

Onchocerca volvulus (Leuckart, 1893) infests man in tropical Africa with an intensity which varies in different localities. In West Africa there are large areas in which a very high percentage of the total population is infested. Prout (1901) in Sierra Leone was one of the first to describe it. The worms live in nodules in the subcutaneous and deeper tissues, and give rise to larvae which find their way into the skin; an infested area of skin may contain vast numbers of larvae, so much so that not even the smallest portion can be removed without numerous larvae being found. Different observers have attributed to the worm an etiological significance in the production of very diverse pathological effects, which depend on the distribution of the worm itself in the body and of the larvae in the skin. Several forms of skin disease, itch, ulcers, as well as glandular enlargements, hydrocele, and elephantiasis, are some of the conditions with the production of which this worm is credited.

Mode of Transmission of Onchocerca.

The transmitting agents of several of the Filariidae are already known, if we accept invasion of the proboscis as evidence of the insects being capable of transmitting; up to the present time, however, no one has succeeded in demonstrating by what means any species of the genus *Onchocerca* is transmitted from man to man or from animal to animal. As a result of investigations carried out at intervals during the past four years I believe that I am now in a position to state that the conditions essential to transmission of *O. volvulus* are fulfilled by a biting insect, a species of the genus *Simulium*, named very appropriately *Simulium damnosum*. These investigations were undertaken in the Konno district of the Sierra Leone

* An address delivered before the Sierra Leone Branch of the British Medical Association.

Protectorate, where the worm is common. More detailed accounts are being communicated to the *Annals of Tropical Medicine and Parasitology*, in which the first experiments were published in February, 1926.

The Konno District.

The Konno district of the Protectorate of Sierra Leone lies to the north of the railway line which traverses the Protectorate from west to east. It is a hilly region drained by several large rivers and a multiplicity of small streams; the hills are in most cases clothed with dense bush right to the summit. Each village has in its immediate vicinity several streams; swampy areas produced by silting up and overflow of the streams are numerous and biting insects are plentiful. The population is largely agricultural, and both sexes spend much time working on farm lands situated in the dense bush; the streams are used for latrine purposes as well as for washing and drinking. The result is a goitrous population and one heavily infected with urinary schistosomiasis; intestinal diseases, helminthic, protozoal, and bacterial, are rife. The following facts concerning the disease caused by *O. volvulus* demonstrate its prevalence and illustrate the kinds of observation made in order to ascertain its pathogenic effects on the population.

The Subcutaneous Nodules.

The character of the subcutaneous nodules produced by *O. volvulus* varies from a smooth, soft, just palpable nodule to a large, irregularly nodular, hard mass of the size of a large walnut. The first type is usually found in the region of the great trochanter, on the ribs, and on the scalp; the second is generally closely associated with joints, more especially the elbow and knee joints; neither type is usually adherent to the skin, but in some cases, especially over the region of the great trochanter, the skin over the nodule is thickened, partly adherent, and polished on the surface from pressure.

Distribution of the Larvae.

The larvae of this species were seldom found by me in the blood, only a rare larva being present occasionally in the blood film, and that probably derived from the infected skin. The larvae are present in the skin, and may often be found there in large numbers, even when no nodules can be discovered. They are not, however, evenly distributed over the body; thus, while of 93 persons whom I examined by making four sections of the skin of each—that is, from the scapular, loin, thigh, and ankle region—over 45 per cent. proved to be infected with *O. volvulus*. The larvae occurred in these sites in the following order of frequency from the highest to the lowest: loin, thigh, scapular region, and ankle.

Diagnosis of Infection.

The presence of the worm in the body may be detected either by puncture of the nodules and the discovery of the larvae in the aspirated fluid, or by cutting off with a razor small pieces of the skin, which are then teased with strong needles in a drop of water, so as to liberate the active larvae; apparently the first discovery of microfilariae in the skin of man by this latter method was made by O'Neill in 1875 on the Gold Coast. The larvae, although they do not live in the blood, have nevertheless to be distinguished from those of *F. bancrofti*, *L. loa*, *A. perstans*, and also from *Ag. streptocerca*, the last named being a skin microfilaria described by Macfie and Corson (1922). It was found in the Konno district that only 40 per cent. of those who had *O. volvulus* larvae in the skin had also subcutaneous nodules, while of those in whose skin larvae could not be found 16 per cent. had nodules. The examination of skin gave, therefore, a higher percentage of positive findings, and it has the advantage of being easier to carry out in natives than puncture of the nodules.

Pathogenic Effects of the Worm.

In view of the fact that many observers have recorded severe lesions of the skin, glands, and, in the case of the American human *Onchocerca*, of the eyes, it was advisable

to ascertain whether similar effects would be found in Sierra Leone.

The Eyes.—Sixty-one cases in whom the eyes were examined and the skin was searched for larvae yielded 29 instances of *O. volvulus* infection. Only 6 of the 61 had any abnormal condition of the eyes and only 4 of these 6 belonged to the infected group. The eye conditions pterygium, blepharitis, and defect of vision were not associated with the presence of nodules in the head, and the last named appeared to be rather associated with advancing years than with the infection with *O. volvulus*. The examination revealed the fact that in the Konno population the eyes did not suffer notably from either toxic or other effects produced by the worm.

The Skin.—In an examination of 60 people 17 were found whose skin displayed no trace of disease visible to the unaided eye. This absence of obvious skin disease did not, however, prove to mean that none of these 17 cases was infected; for in point of fact no fewer than 8 of them were proved to be infected with *O. volvulus* by the discovery of its larvae in the skin. It was thought that the age of the person might have some bearing on the question, on the assumption that skin disease as a result of infestation might be a transitory condition on the one hand or a late developing one on the other. Against this, however, was the fact that the youngest case showing larvae in a good skin was 24 years of age, while the oldest was 51. The conclusion reached was that infection with *O. volvulus* does not necessarily connote obvious disease of the skin, although it may often coexist with it.

The Glands.—In 68 cases the glands were examined, and it was found that of those having *O. volvulus* larvae in the skin only 27 per cent. had enlarged glands, while of those not having larvae in the skin 32 per cent. had enlarged glands. Admitting that such skin examination as described must inevitably fail to reveal more than a fair percentage of cases, it may be said that on the whole this investigation did not yield definite evidence of pathogenic effects on the glands.

Thus neither in the case of the eyes, the skin, nor the glands did this Konno population show pathological effects definitely and solely attributable to *O. volvulus* infection. It is nevertheless probable that in localities where hyperinfection with the worm occurs a different clinical picture may be produced; very suggestive of this is the work of Ouzilleau (1913), who ascribes to the agency of *O. volvulus* lymphatic gland enlargement, hydrocele, and elephantiasis, occurring in a region in the Congo where *F. bancrofti* could not be found while *O. volvulus* was common. Dyce Sharp (1926), who has made a study of onchocerciasis in Nigeria, observes that the larvae of *O. volvulus* occur with great frequency in hydrocele fluid, and that, while possibly innocuous, they may well stand in some causal relationship to this condition as well as to elephantiasis.

Experiments to Discover the Transmitting Agent.

The investigation of the problem of transmission was begun in 1923-24 and continued in 1925 and 1926. The question was approached from the view that, as the larvae occur not in the blood but in the skin, any blood-sucking arthropod to be capable of transmitting it would have to damage the skin and dislodge the larvae in its efforts to reach blood. The Congo floor maggot *Auchmeromyia luteola*, common in Konno houses, seemed a possible agent in so far as producing damage to the skin is concerned, and specimens of this were first dissected, but no larvae were found. At several villages in December, 1923, and January, 1924, it was observed that *Simulium damnosum* Theob. was biting viciously and in great numbers beside the streams; it was noticed that although this species attacked the skin readily it was slow in reaching the blood and appeared to have difficulty in getting through the skin; this delay led to the belief that, in biting, this insect inflicted considerable damage on the skin, a belief which was strengthened by an examination of the biting apparatus of the fly. One hundred specimens captured were examined for larvae in the gut, but nothing was found, and owing to pressure of other work the search was abandoned temporarily.

Discovery of *O. volvulus* Larvae in the Gut of *Simulium damnosum*.

In 1925 at another village the search was resumed, and this time with success; infection of the gut with larvae morphologically identical with those of *O. volvulus* was discovered in 20 out of 780 flies—that is, in 2.6 per cent.—

FIG. 1.—*Simulium damnosum*
Theob.

captured on unselected boys. Two men known to be infected with larvae of *O. volvulus* in the skin and in whom no other microfilariae could be detected were then submitted to the bites of the flies; as a result the percentage of gut infection in the fly rose at once to 17. The most heavily infected person was then submitted alone to the flies, the following regions being exposed to them in successive experiments: the loins and upwards gave 28 per cent. of gut infections; the waist and hips only gave 59 per cent. of gut infections; finally the person was exposed so that the flies could bite only on a four-inch-wide band of skin round the body, having the nodules, which were present near each trochanter, in the centre of the band; this experiment gave a positive gut infection in the flies of 80 per cent.

Development in the Thorax of *Simulium damnosum*.

During the dissection of the thorax of 1,320 wild *Simulium* caught on unselected boys 15, or 1.1 per cent., were found to have developmental forms of some nematode larva present in the muscles of the thorax. Extensive examinations of samples of the population and of animals and a study of the biting habits of the fly led to the conclusion that the thoracic forms found were in all probability derived from *O. volvulus*. Flies fed on selected cases as described above were kept alive as long as possible and the thorax dissected; the effect was seen in a progressive rise of the percentage of thorax infection, first to 10 per cent., then to 32 per cent., and finally, in flies fed on the four-inch band in the heavily infected case, to the high figure of 82 per cent. No development actually into the head was observed in the course of these experiments, although one form was found partly embedded in the posterior part of the head. It was therefore impossible to make any definite statement at this time beyond recording the fact that the larvae of *O. volvulus* are readily ingested by *S. damnosum*, and that development up to a certain stage occurs in the gut and thorax of this blood-sucking insect.

Development of *O. volvulus* in the Head of *Simulium damnosum*.

In 1926 a further series of experiments was carried out and evidence was obtained that the development in the thorax continues with progressive increase in size and morphological modification till the larvae, having invaded the head region of *Simulium*, finally reach the proboscis. They enter the labium of the fly, where they remain coiled up and ready to emerge, which they do at once when provided with favourable conditions. The experiments are too numerous and long to give in detail here, but they may be summarized briefly as follows:

In six experiments 502 flies were allowed to feed freely on the heavily infected case referred to above; of this total 201 were dissected at a period later than the third day, and in the thorax of 127 of them (63 per cent.) developmental forms were discovered; in the head developmental forms were found in 34 (16 per cent.). The earliest infection of the posterior part of the head was five days, and of the anterior part of the head seven days, after the infecting feed. The development of *O. volvulus* in the fly from the time it is taken up from the skin until it reaches the labium and is

mature and presumably capable of infecting a human being occupies about ten days. During this time the larva has undergone great changes in form; not only so, it has also increased in size from about 250 μ long by 7 μ broad to over 760 μ long by 20 μ broad.

Summary of Development in the Fly.

The skin forms taken into the gut of *Simulium* accumulate at the margin of the blood coagulum lying between this and the gut wall. They are very active and the majority pass out of the gut within twenty-four hours and may be found in the posterior part of the thoracic muscles in forty-eight hours. They have altered completely in shape, having increased in width and acquired a characteristic caudal spine-like appendage which may be either straight or much curved; they have also lost a great deal of their mobility. Several moults appear to occur before the form is reached which is capable of invading the head. The advanced thoracic forms show progressive stages of development of the alimentary canal, which is differentiated first into anterior and posterior portions, of different calibre and separated from each other; these unite later to form the uniform gut of the proboscis form, which runs from the head to open in a slit-like anus in front of the tail.

The Effect of Temperature on Development.

Differences in the rate of development were noted at different temperatures. It became evident that, although almost identical percentages of flies had acquired infection at the higher and lower temperatures used, the lower temperature had a retarding influence on development to such an extent that the flies usually died before the head became infected. Thus of 78 flies which lived for six days or over and were dissected, the absolute maximum temperature being 88° F., the absolute minimum 49°, and the average minimum 58°, only 5—that is, 6 per cent.—became infected in the head. Better results as regards head infection were obtained with an absolute maximum temperature of 87°, an absolute minimum of 63°, and an average minimum of 68°. In these circumstances, of 52 flies which lived six days or over and were dissected, 16—that is, 31 per cent.—were found infected in the head.

FIG. 2.—Diagram to illustrate the development of *O. volvulus* larvae in the tissues of *Simulium damnosum*. I, Larva from infected skin. II, Larva in mid-gut. III, Larva in thoracic muscles (early stage). IV, Larva in thoracic muscles (late stage). V, Larva in head and labium. A, Antenna. B.C., Blood coagulum. T.M., Thoracic muscles. L, Labium. Le., Labrum-epipharynx. H., Hypopharynx. M., Mandible. Mx., Maxilla. Mx.P., Maxillary palp.

Ovarian and Parasitic Development.

In flies allowed to feed on severely infected skin and then kept in tubes a heavy mortality ensued. Part of this appears to be due to the large number of worms developing in the fly's tissues; part was attributable to the ill effects of retention of the ova owing to the experimental conditions not being suitable for oviposition. Low temperature retarded the development of the ovaries as well as of the

parasites, and the two processes presented a definite correspondence in developmental rate. A correspondence of this kind is to be expected if the fly, after ovipositing, is to be capable of infecting at the next time of biting.

Emergence of Larvae from the Head of Simulium damnosum.

When the larvae had taken up their final position in the labium and were fully developed they were observed to emerge spontaneously into a drop of monkey serum which had been warmed; this phenomenon evidently depends on a definite attraction exercised by such serum, because a drop of warmed normal saline solution did not produce the same stimulating effect on them. Apart from such spontaneous emergence the larvae were seen to emerge when very light pressure was applied to the head region with a needle.

Experimental Inoculations into Animals.

Two monkeys were inoculated intra- and sub-cutaneously, the first in the flank and the second in the head, with advanced forms of larvae contained in the heads of flies. Neither of the monkeys showed any immediate reaction, the incisions healing by first intention, nor has any development so far become apparent. As, however, only two months have elapsed since the first animal was inoculated it is too early to express any opinion as to the ultimate result.

The Habits of Simulium damnosum.

Simulium damnosum Theob. in the Konno district is a small stout fly about 3 mm. long, almost black, and of inconspicuous appearance. It belongs to the same group of flies as those which are sometimes called Buffalo gnats, Turkey gnats, and black flies, and is common in many parts of equatorial Africa. It occurs in Uganda, where it is known as Mbwa, and in the Sudan, where it is called Kiltib; in the Konno it is called Mooli, and in Lokkoh, Poondoo gootena=short mosquito. It is a notoriously vicious biter and is much dreaded in regions where it is numerous. The fly is to be found in the bush and grass in the vicinity of water; collectors always went to the waterside in order to find it easily. It dislikes strong sunlight and heavy rain; it likes shade and humidity; a great deal of its movement is by crawling and hopping, rather in the manner of a flea. In tubes it moves towards the light, a fact which can be made use of in changing flies from one tube to another. Only the female was found biting, and the biting habit is diurnal. It proved unwilling to come out far in strong sunlight to feed; it preferred to feed, if situated in fairly open country, during the hours when the sun was not strong, the early morning and late in the afternoon. It makes no sound and bites most frequently low down on the body, from the waist downwards, choosing especially shaded portions of the legs. The presence of overhead shade gives it an opportunity of biting higher up on the body. Palm-tree climbers state that it bites them in the dense palm bush even when they are far above the ground. The fly takes from one and a half to five minutes to engorge; when it has fed it looks remarkably distended, and is so heavy that it flies with difficulty. It was not found to follow man for any distance, and it is not a fly which attracts the attention by flying round the face. One may, in fact, walk along a path without seeing a single fly, although in the grass a yard or two away there may be dozens of them concealed. For this reason many Europeans who pass from rest house to rest house, and do not frequent the streams and marshy areas, may be entirely unaware of the presence of this noxious insect.

With this brief account of the habits of *Simulium damnosum* we may conclude the section dealing with *O. volvulus*. From the experiments recorded it appears extremely probable that this worm is transmitted from man to man by the bite of *Simulium damnosum*. At the same time it must be stated that the only unequivocal evidence will be that furnished by recovery of adult worms from animals or man infested by larvae which have developed in laboratory-bred flies as a result of feeding upon *O. volvulus* infested human beings. Such evidence

I regret that I am not in a position to place before you, as up to the present time I have not been able to obtain laboratory-bred flies.

We may now pass on to consider very shortly two other species of the genus *Onchocerca*—namely, the American human parasite *Onchocerca caecutiens*, and a parasite of domestic cattle, *Onchocerca gibsoni*.

Onchocerca caecutiens.

This species was erected by Brumpt not so much on morphological as on biological grounds; it is a parasite of man in certain parts of Central America, and produces in man worm nodules which occur almost exclusively on the head. Brumpt (1919) named this species *caecutiens* ("blinding") because of the very remarkable account given by Robles in Guatemala of the severe eye symptoms and lesions which are associated with its presence, and which disappear with dramatic suddenness after removal of the nodules from the head. Robles (1919) records several instances in which the nodules formed by this species had eroded right through the cranial vault and were lying directly upon the meninges. On epidemiological grounds Robles several years ago suggested that two species of *Simulium* locally called "coffee flies"—that is, *S. dinelli* and *S. samboni*—were possibly the transmitting agents of this worm.

This American species is considered by some to be morphologically identical with the African one which has been discussed above. One of the points upon which Brumpt lays stress in the differential diagnosis of the two species is that the nodules caused by the American species are situated in the head in 99 per cent. of cases, whereas the African species causes nodules which in only 1 per cent. of cases are situated in the head. I may record here the fact that in one village in the Konno district I recently found that many of those who had nodules had them in the head. In a population of 66 examined, 33 (50 per cent.) presented nodules in some region of the body. Of the 33 who had nodules, 8 (24 per cent.) had them on the head, the diagnosis being made by puncture. On searching for an explanation for this unusual incidence two points were noted which appeared suggestive. The first was that this little village of eleven houses occupied less space than any other village of the same number of houses seen by me; the houses were arranged in a close ring practically touching each other. The second fact was that the village was shaded by large trees, as was also the path down to the river beside which the village was situated. In such a place as this it was possible for *Simulium damnosum* to attack the upper parts of the body without exposing itself to the sunlight. I concluded that it might be because of the local conditions as regards high shade that so many persons in this village presented nodules on the head. From inquiries which I have made from persons familiar with the conditions on the coffee plantation in Guatemala it appears that coffee in that country is most commonly grown under overhead shade. This fact might partly explain the incidence of the nodules of this species in the head, more especially if the lower parts of the body are covered by trousers and some kind of footwear.

Onchocerca gibsoni.

Of the numerous species of *Onchocerca* affecting domestic animals that which produces effects most similar to those of *O. volvulus* is *O. gibsoni* Cleland and Johnson, 1910. This species is a parasite of cattle; it produces worm nodules which damage the meat and render it unsaleable. Australia is one of the greatest sufferers from the effects of this species, and its presence in cattle entails a very heavy annual loss. Gilruth and Sweet (1911) state that no cattle station in Queensland is entirely free from the parasite, and that on some stations the infection amounts to 100 per cent. The worms live in nodules of varying size, some of them being subcutaneous and palpable or even visible, while others are situated deep in the inter-muscular planes, in the connective tissue. They occur in such numbers in many cases that, although there is no evidence that either infection or injury to the health of man could result from consumption of meat containing

them, a carcass is rendered so unsightly by them that it is unfit for use. This has in the past led to the condemnation of such infected carcasses at the ports of London and Liverpool. It has been estimated (Commonwealth of Australia, 1917) that the discovery of the source of infection with worm nodules may eventually save Queensland over £1,000,000 a year if the grazier is aided in preventing infection.

Very little experimental work appears to have been done in Australia with any species of *Simulium* in connexion with the genus *Onchocerca*, although very numerous unsuccessful experiments are recorded with the larger biting insects such as tabanids. Yet *Simulium* is by no means unrepresented in Australia, several species having been described, one of which is suggestively named *furiosum*. Lea (1917) records a species of *Simulium* very abundant in the south-eastern parts of South Australia, occurring in thousands and causing series annoyance to horses and cattle. In view of the results obtained with *Simulium damnosum* and *O. volvulus* I would suggest that a species of *Simulium* may prove to be the carrier of *O. gibsoni* in Australia, or at least that this work on *O. volvulus* points to the desirability of carrying out a series of similar experiments with various species of *Simulium* and *Onchocerca gibsoni* in Australia.

REFERENCES.

1. Brumpt, E. (1919): *Bull. Soc. Path. Exot.*, vol. 12, No. 7, p. 461.
2. Commonwealth of Australia Advisory Council of Science and Industry, Melbourne (1917), *Bull. No. 2, Abs. Rev. app. Ent. V. 7, Ser. B, pt. 1, p. 14.*
3. Gilruth, J. A., and Sweet, G. (1911): *Onchocerca gibsoni*, Commonwealth of Australia publication by direction of Minister of Trade and Customs, p. 3.
4. Lea, A. M. (1917): *Trans. Proc. Roy. Soc. S. Australia*, Adelaide, 41, December 24th, p. 663; *Abs. Rev. app. Ent. V. 6, Ser. B, pt. 9, p. 178.*
5. Macfie, J. W. S., and Corson, J. E. (1922): *Ann. Trop. Med. and Para.*, V, 16.
6. O'Neill, J. (1875): *Lancet*, vol. i, No. 8.
7. Ouzilleau (1913): *Byam and Archibald, Prac. Med. Trop.*, Vol. 3, p. 1953.
8. Prout, W. J. (1901): *BRITISH MEDICAL JOURNAL*, No. 2091, p. 209.
9. Robles, R. (1919): *Bull. Soc. Path. Exot.*, Vol. 12, No. 7, pp. 442-460.
10. Sharp, N. A. Dyce (1926): *Trans. Roy. Soc. Trop. Med. and Hyg.*, V, xix, No. 7, p. 373.

ANALYSIS OF A SERIES OF CASES OF CARDIO-VASCULAR SYPHILIS.

BY

H. L. HEIMANN, B.A., M.D., M.R.C.P.,

HONORARY ASSISTANT PHYSICIAN, JOHANNESBURG GENERAL HOSPITAL;
LATE RESIDENT MEDICAL OFFICER, NATIONAL HOSPITAL FOR
DISEASES OF THE HEART, LONDON.

THIS article deals with 105 cases of cardio-vascular syphilis among in-patients of the National Hospital for Diseases of the Heart, London, during the years 1919 to 1923 inclusive. An inquiry was sent to each patient so as to ascertain, as far as possible, his subsequent history, and, where practicable, the patients were re-examined in June, 1923, on which date 21 cases could not be traced. All the patients had positive Wassermann reactions in the blood serum. The series includes three patients each with a history of acute rheumatism, none of whom had mitral stenosis. One case terminated in an infective endocarditis. The symptomatology and course of these cases were not unlike the others, and they have not been excluded. The youngest patient was aged 22, the oldest, 71, the average age being 48 years. There were 97 males and 8 females—an approximate proportion of ten to one. Of the 105 patients, 31 had a history of chancre, and the average time between infection and admission to hospital was twenty-four and a half years.

Cardio-vascular syphilis in the first twenty years of its course is a latent disease; once it manifests its symptomatology its progress is rapid, as is indicated in dealing with the mortality. Valvular involvement in the form of aortic regurgitation occurred in 81 patients; no organic valvular lesion was found in the remaining 24. The critical symptoms, single or multiple, were as follows: shortness of breath, 55 cases; pain (cardiac), 44; giddiness, 17; palpitation, 16; fainting attacks, 11; cough, 4; haemoptysis, 1; swelling of legs, 1.

The relation of these symptoms and signs to the presence or absence of valvular lesions may be tabulated as follows.

Signs and Symptoms in 105 Cases of Cardio-vascular Syphilis: Group I, with Regurgitation; Group II, with no Valvular Lesion.

(The percentages are of the respective groups, not of the total cases.)

Signs and Symptoms.	GROUP I (81 Cases).		GROUP II (24 Cases).	
	No.	Per cent.	No.	Per cent.
Dizziness and giddiness	34	42	13	54
Faintness	4	5	3	12
Shortness of breath	71	88	17	75
Loss of weight	3	4	2	8
Night sweats	2	2.5	—	—
Swelling of legs	20	25	3	12.5
Pain—Slight	30	37	10	41
.. Moderate	13	16	5	20
.. Angina pectoris	9	11	1	4
Cough	13	16	—	—
Haemoptysis (no aneurysm)	7	9	2	8
.. (with aneurysm)	3	4	—	—
Epistaxis	2	2.5	—	—
Cyanosis	16	20	8	33
Pallor	32	40	2	8
Character of impulse:				
Faint	8	10	3	12
Slapping	12	15	3	12
Heaving	33	41	3	12
Signs of cardiac failure	20	25	3	12
Extra-systoles	6	7.5	4	16
Superficial arteries thickened	70	87	17	80

The average age of patients in Group I was 47 years; of those in Group II 49 years. The average time of infection before admission was: in Group I 25 years (24 cases); in Group II 24 years (7 cases).

Enlargement of the heart was detected in the groups of cases to the following extent. In the first group (of 81 patients with valvular involvement) slight enlargement of $3\frac{1}{2}$ inches or less from the mid-line to the left occurred in 2 cases (3 per cent. of the group); of moderate degree, 4 to $4\frac{1}{2}$ inches from the mid-line, in 13 cases (16 per cent.); and of great degree, or more than $4\frac{1}{2}$ inches, in 62 cases (77 per cent.). In the second group (of 24 patients without valvular involvement) the corresponding figures were: slight enlargement, 6 cases (25 per cent.); moderate, 4 cases (17 per cent.); great, 10 cases (42½ per cent.). Enlargement of the heart half an inch to the right of the right margin of the sternum was found in the first group in 21 cases (26 per cent.); an increase of 1 inch in 18 cases (23 per cent.); and an increase of $1\frac{1}{2}$ inches in 7 cases (9 per cent.). In Group II the figures were: half an inch in 6 cases (25 per cent.); 1 inch in 2 cases (8 per cent.); $1\frac{1}{2}$ inches in 1 case (4 per cent.). The average systolic pressure in the two groups was 154 in Group I and 141 in Group II. The pulse pressure was 86 in the first group and 52 in the second, while the difference between the systolic pressures of the leg and arm was 51 in the first group and 28 in the second.

The symptomatology of the two groups is not very dissimilar. There were no complaints of cough or bleeding from the nose in the patients who had no organic valvular lesions. Shortness of breath, the earliest symptom of failure of compensation, was somewhat more prevalent among the valvular group. Unusual symptoms were night sweats, haemoptysis (without aneurysm), and loss of weight. There was no evidence of pulmonary tuberculosis or of secondary infection of the cardiac valves in these cases.

Clinical Signs.

Thickened superficial arteries were not invariably present. The average systolic blood pressure in the brachial arteries was about 150 mm. of mercury; extremes (110 to 200) occurred, but were exceptional. At this particular time of life (45 to 50) arterio-sclerosis of a different type exists—the arterio-capillary fibrosis of Gull and Sutton. This is accompanied by a blood pressure higher than 150 systolic as a rule.¹ Where a systolic blood pressure of above 150 was found in the syphilitic cases there were probably other factors—either a high degree of aortic incompetence, or a complication of this diffuse form of