important. There is no specifically acting remedy as far as we know, and in its usual mild form no medicinal treatment is needed for the mouth disease. The affected teats and hoofs may, however, occasionally benefit by expert veterinary treatment.

NODULAR INTESTINAL DISEASE OF CATTLE.

By WALTER JOWETT, F.R.C.V.S., D.V.H., Cape Town.

NODULAR disease of the intestine of the sheep—*oesophagostomiasis* (or “knopziekte,” as the disease is popularly termed in South Africa)—is quite prevalent in this country, being met with, as far as the available evidence on the subject shows, in many of the districts in which sheep farming is carried on extensively. Whether the closely related nodular disease of the intestine of the bovine animal is equally prevalent, one is not in a position to state with any degree of certainty, but the writer, when holding *post-mortem* examinations on cattle, has encountered the disease on several occasions in the Cape Peninsula during the past few years.

A short account of this peculiar nodular intestinal disease of cattle is here given. The photographs and drawings illustrating the note were prepared from material furnished by one very well-marked case recently encountered in the vicinity of Cape Town.

Nature of the Disease.—The disease now under consideration is characterised by the formation of many small lumps or nodules in in the sub-mucous tissue of the intestine. These nodules are usually round, firm, pea or shot-like, and, as a rule, they vary in size from that of a pin's head to that of a pea. Occasionally somewhat larger nodules are encountered, but the size of the majority usually lies within the limits mentioned. They may be scanty in numbers, but not uncommonly hundreds of such nodules are present, in which event, of course, their presence can hardly fail to be noted if the intestines be examined. They are often apparent even before the intestines are opened, showing through the outer (serous) coat sometimes quite distinctly. They are, however, much more in evidence when the gut has been slit opened and cleaned. When this is done a number of small lumps or projections may be seen in the wall of the gut, the lining membrane of the latter being usually continued in an uninterrupted layer over their surface, as if a number of small or large peas had been placed within the layers of tissue forming the wall of the intestine. Frequently in the case of the older nodules, and sometimes even with fairly recent ones, the mucous membrane is considerably thickened at the site of the nodule, but ulceration of the membrane covering the nodule does not seem to be of very frequent occurrence in the disease in cattle.

The commonest site of these nodules is in the sub-mucous tissue of the small intestine, but they are encountered also quite frequently in the large gut, occupying here, likewise, a similar position beneath the mucous membrane, between the latter and the muscular coat, and encroaching more or less on one or other or both of these layers.

The colour of the nodules vary in accordance with their age. The smaller and younger nodules are generally black (*hæmorrhagic*), the

medium-sized ones are either uniformly black or else they are white and black, whilst the larger and older nodules are either uniformly white or yellowish, or they may have greenish-yellow contents. Still older nodules are generally hard and fibrous; sometimes one finds them composed of firm, fibrous walls enclosing contents which may be caseous or in part or wholly calcareous.

Cause of the Disease.—Each of the recently formed, or comparatively recently formed, nodules encloses one minute larval nematode, surrounded by cells which have accumulated in response to, and as a part of, the inflammatory process excited by the presence of the parasite.

In size the young nematode in the nodule measures only about 2

FIG. 1.

Larval nematode from sub-mucous nodule in intestine of calf.

A. Natural size. B. Magnified about 40 diameters. Fresh preparation.

to 3 mm. (roughly about $\frac{1}{12}$ th of an inch) in length, and it is therefore not an easy matter to detect its presence unless the vision be aided by a microscope.

Old nodules, as already remarked, frequently contain a yellowish or greenish-yellow material surrounded by fibrous walls, and in such nodules the demonstration of the parasite is rather more difficult. In still older nodules, with dry, firm, fibrous consistency, it is usually impossible to demonstrate the parasite for the reason that it may be no longer present therein, having migrated to the lumen of the intestine, there to become mature and to complete its life-cycle.

Life-cycle of the Causal Parasite.—The worm, as met with in the

sub-mucous nodule of the intestine, is still in the larval condition ; here it undergoes ecdysis, and in time becomes an immature adult, when the cyst (nodule) usually ruptures, allowing the nematode to escape into the lumen of the gut. Should this not happen, the young nematode still imprisoned in the nodule ultimately dies, degenerates, and finally may become impregnated with lime salts.

Whilst it remains in the nodule the parasite shows no sexual differentiation, but after it has been liberated from the cyst (nodule) it undergoes further changes, growing, and developing finally into either a male or a female adult nematode. The two fully formed sexual adults then copulate in the lumen of the gut of their host.

The fertilised ova of the female in the case of a closely related

FIG. 2.

Drawing of head end of same.

A. Cuticular enlargement or buccal ring, and vestibule or buccal capsule. B. Cervico-ventral enlargement. C. Oesophagus. D. Intestine. (× about 100 diameters.)

parasite (oesophagostome) of man and of the monkey already show segmentation whilst still in the uterus of the worm, and the state of affairs in the case of this parasite of the bovine is probably similar. The eggs pass to the exterior with the fæces of the host, and there undergo certain developmental changes, the length of time before the next definite stage is reached depending no doubt upon the suitability, or otherwise, of the surrounding temperature and conditions of humidity, a supply of oxygen in the form in which it occurs in the atmosphere being possibly essential at this stage of development.

In time each egg gives rise to a young embryo. The embryo gains access to the intestine of a new host (ox) with soil, food, or water.

Having gained this position, it burrows into the lining membrane of the gut, or, according to some authors, reaches the ultimate site it occupies in the sub-mucous tissue by means of the blood-stream. Be that as it may, the embryo is finally arrested in the sub-mucous coat of the intestine, where it gives rise to the formation of a hæmorrhagic cyst—the nodule, so characteristic of the disease.

In the cyst (nodule) the larva grows and undergoes certain developmental changes, but, as already pointed out, it does not acquire sexual characteristics. In this site it is provided merely with an alimentary canal running from the mouth to the anus as a simple tube, the anus being terminal, or, rather, sub-terminal. Eventually the cyst ruptures, the young worm passes into the lumen of the intestine, where it becomes a fully formed adult and acquires sexual

FIG. 3.

Drawing of tail end of same.

D. Intestine. E. Anus.

organs. Finally the adult male and female worms copulate, eggs are produced by the fertilised female, these pass out with the fæces of the host (ox), and so the life-cycle goes on.

Identity of the Parasite.—The nodular disease of the intestines of bovines was first described by Drechsler, of Munich, in 1876. Saabe afterwards confirmed the findings of Dreschler. Ostertag states that he has frequently seen the sub-mucous nodules in the intestines of cattle slaughtered at the Berlin abattoir.

As to the identity of the larva there has been much diversity of opinion, it being, of course, impossible to determine the species of a given parasite of this nature by mere examination of larval specimens alone, and, as already pointed out, it is only such immature worms which are present in the sub-mucous nodules. The determination of

the species therefore rests on the result of examination of adult and sexually mature worms—the males especially—which are present in the intestinal contents of the affected animals. These, however, are not invariably present in the lumen of the gut concurrently with the nodules in its walls; moreover, it is somewhat difficult at times to isolate worms so minute as those now under consideration from the large mass of material contained in the bovine intestine. The adult parasite occurring in the intestinal contents, even when fully developed, measures only 1·5 to 2 cm. in length (roughly about $\frac{3}{5}$ th to $\frac{4}{5}$ th of an inch), whilst the larva in the nodules is only $\frac{1}{12}$ th of an inch long.

Strose and some of the earlier writers who studied this condition regarded the small nematode present in the nodules as an ankylostome (a. bovis), Von Ratz being one of the first to consider it as representing the larval stage of a different species of parasite, viz., an œsophagostome (*œsophagostomum inflatum*).

FIG. 4.

Micro-photograph of horizontal section through one entire nodule.

Part of the contained larval nematode is here shown near the centre of the nodule (it is somewhat more apparent in the next figure—5) surrounded by round cells, and externally by fibrous tissue. (× about 25 diameters.)

Marotel, who studied the question of the identity of the parasite afresh in France, has definitely shown that the nematode present in the nodules is a larval œsophagostomum. He considered that the particular species concerned in the case of cattle in France is the *œsophagostomum radiatum*. According to Marotel: "Each nodule encloses a young œsophagostome of variable shape and development. The length of the worm does not exceed 3 mm. in the case of the ox. [This measurement, of course, refers only to the worm found in the nodule.] As long as they measure less than 4 or 5 mm. these larvæ correspond to three types—those of 1 mm. resemble strongyles (strongyliform larvæ); those of 2 mm. remind one of ankylostomes (ankylostomeform larvæ); those of 3 mm. are comparable to œsophagostomes (œsophagostomeform larvæ). Finally, the individuals which exceed 4 or 5 mm. are perfect, but still immature, œsophagostomes; in order to reach the adult state, to copulate and

to reproduce, they are obliged to quit the nodules and to gain the lumen of the intestine."

The evolution of the *œsophagostome* thus comprises two parts, one which is effected in the interior of the intestinal nodules, and another which is passed in a free state in the intestinal cavity, the first varying in length in different species.

From the more recent researches of Cuillé, Marotel, and Panisset, however, it would seem that the particular species of *œsophagostome* responsible for the causation of this nodular disease of cattle constitutes, in reality, a new species, to which the name of *œsophagostomum biramosum* has been given.

Amongst the main features which distinguish *œsophagostomum biramosum* from *œsophagostomum radiatum* are: (1) the possession by the former of a cervical swelling, somewhat hour-glass-shaped

FIG. 5.

The same more highly magnified.

($\times$ about 50 diameters).

(The nematode has shrunk somewhat in the course of the preparation of the tissue for sectioning).

but non-vesicular; and (2) there are two distinct branches to each of the posterior ribs in the caudal bursa of the male, the outer division of each main branch of the posterior (dorsal) ray being, apparently, better marked and somewhat longer than is the case in *œsophagostomum radiatum*.

Before proceeding further one may state that the larva found in the intestinal nodules of the South African cattle is, as far as one can judge, identical with the parasite depicted by Marotel as present in similar nodules in the intestinal walls of cattle in France, and as far as this investigation is concerned the present writer regards the parasite responsible for the diseased condition here dealt with as an *œsophagostome*.

The accompanying illustrations accurately depict the appearance

presented by the parasite present in the nodules. At A (fig. 1) the small line will give an idea of the actual size of the parasite as encountered in this position, whilst at B (fig. 1) such a parasite is shown magnified some 40 to 45 diameters. Figs. 2 and 3 show the head and tail end of the larval nematode magnified about 100 diameters, whilst fig. 4 is a micro-photograph of a horizontal section of one complete nodule. Part of the larva is here shown near the centre of the nodule, this being surrounded by many round cells, whilst a well-developed fibrous wall limits the nodule externally. Fig. 5 shows the same section more highly magnified.

Symptoms.—With regard to the symptoms exhibited by cattle the subjects of the nodular intestinal disease, much depends upon (1) whether the infestation is a heavy one or otherwise, (2) whether it is recent or of some standing, and (3) the degree of resistance which the host is able to offer against the harmful effect of the parasitic invasion. Marotel says: "Clinically it reveals itself by the appearances of a chronic enteritis, watery diarrhœa, progressive wasting, anæmia, and cachexia; it terminates usually in three or four months by death in coma, and its gravity is such that in certain cases the mortality reaches the startling figure of 50 per cent."

From this description it is apparent that the disease, at any rate as met with in France, is of considerable economic importance. The present writer, however, is inclined to think that the nodular disease of the intestines of bovines encountered at the Cape is somewhat less grave than the picture drawn by the French investigator above quoted.

It is not unusual when conducting *post-mortem* examinations of cattle slaughtered for food purposes, or of those which have succumbed to some rapidly fatal disease other than the one here under consideration, to find nodules quite numerous present along the course of the intestinal tract, and yet such animals may be in quite good condition and have shown no very obvious symptoms of illness prior to death. There can be little doubt, on the other hand, that where the parasitic invasion is a heavy one, or when it occurs in an animal not in very robust condition, diarrhœa and symptoms of chronic intestinal irritation will be apparent, and attended ultimately with more or less anæmia and wasting, and occasionally perhaps by death. Such termination, however, is probably not of very frequent occurrence. Obviously, a heavy invasion by the parasite referred to cannot do otherwise than impair the health of the host to a more or less appreciable extent, and interfere more or less considerably with its nutrition and general well-being.

It seems justifiable to ascribe some of the diarrhœas of cattle—often, seemingly, of obscure origin—to this cause. Moreover, it is well recognised that the lesions excited by the parasite may form the starting points of other diseases. The nodules may form foci or portals of entrance for various micro-organisms normally occurring in the intestinal tube, and which, though harmless under ordinary conditions so long as they remain in the position named, *i.e.*, in the lumen of the gut amongst the contents of the latter, may become decidedly pathogenic once they have gained access

through a wound or abrasion of the lining membrane of the intestine (or by any means allowing of their passage in considerable numbers) to the general circulation.

Differential Diagnosis.—The only disease with which it is at all possible that the above-described lesions may be confounded is tuberculosis of the intestine, and this mistake is hardly likely to be made by anyone who is in the least acquainted with the lesions of the malady last mentioned. However, examination of the mesenteric lymphatic glands will speedily settle any doubt which may exist, for whilst these glands are invariably involved in intestinal tuberculosis they are intact in the case of the nodular intestinal disease (œsophagostomiasis), provided, of course, that the latter is not complicated with some other malady involving the intestinal lymph glands.

THE AGGLUTINATION TEST IN THE DIAGNOSIS OF BOVINE CONTAGIOUS ABORTION.

By Sir JOHN M'FADYEAN and STEWART STOCKMAN, London.

IN a previous article¹ we showed that the blood-serum of animals affected with contagious abortion might agglutinate abortion bacilli even in dilutions of 1 in 800, and that as a rule the serum of normal animals was not agglutinative in weaker dilutions than 1 in 10. At that date we did not feel justified in drawing any very firm conclusion regarding the reliance that might be placed on this method of diagnosis in the circumstances of actual practice, for it was obvious that a very large number of comparative tests would have to be made with serum from normal and from infected subjects in order to furnish the data on which a reliable judgment might be based. We are now in a position to report the results of further tests embracing nearly 700 animals.

Technique.—In all cases the bacilli employed in the tests have been obtained from cultures on serum-agar, with or without a small proportion of glycerine. As a rule the cultures have been young, that is to say, not incubated much beyond the time at which the maximum amount of growth had been obtained. The liquid in which the bacilli have been suspended has been distilled water containing .8 per cent. sodium chloride and .5 per cent. carbolic acid. The bacilli were not previously killed by heat or otherwise. Some comparative tests showed that the result was practically the same when simple saline solution without carbolic acid was used, but, of course, the omission of the acid would leave considerable risk of a disturbing turbidity produced in the liquid by the multiplication of accidental bacteria during the sojourn of the tubes in the incubator at 37° C. The emulsion or suspension is at first made of a greater turbidity than is ultimately desired, and after it has been filtered through filter-paper to arrest all visible clumps it is diluted until, when viewed in

¹ See Journal of Comparative Pathology and Therapeutics, Vol. XXII., 1909, p. 264.