# Dipping and Tick-Destroying Agents

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## SYNOPSIS OF PREVIOUS REPORTS.

The following is the third of the reports prepared by Lieut.-Col. H. Watkins-Pitchford, Government Bacteriologist, Natal, on Dipping and Tick-Destroying Agents. The previous reports were published in the *Natal Agricultural Journal*; and in view of the fact that the majority of readers residing in the Cape Province, Transvaal, and Orange Free State, as well as in other parts of South Africa, have not had the opportunity of acquainting themselves with the full details of Mr. Pitchford's investigations in connection with dipping, and also to serve as an introduction to the present report, the following summary has been prepared of the results of investigations contained in Mr. Pitchford's former two reports.

*First Report.*—The object of this report was to show the efficacy of certain preparations intended for the dipping and spraying of cattle, the main object of the inquiry being to ascertain the frequency with which such dipping agents could be effectively applied for the destruction of ticks without risk or detriment to the animals concerned. The conclusions arrived at, therefore, were based not only upon the reliability of a dip as a tick-destroying agent for general use at short intervals, but chiefly upon its ability to permit re-application at a short interval without incurring damage to the animal system. The tick-destroying agents tested were as follows:—(1) Cooper's "Tixol"; (2) McDougall's Dip; (3) Quibell's Dip; (4) Cooper's Dowder Dip; (5) Demuth's Dip; (6) Newton Chambers' "Izo-Izal"; (7) Thomas' Dip; (8) Holmes' Paste Dip; (9) "laline Sheep Dip; (10) Electrolyzed Sea-water; (11) Arsenite of Soda; (12) Erkenbrach's Paste Dip; (13) Alderson's Dip; (14) "Laboratory Dip".

The question of interval between dippings has been considered of much importance in view of the life history of the tick, especially of the brown tick (*Rhipicephalus appendiculatus*), so frequently responsible in one of its developmental stages for the transmission of East Coast fever; and the interval, therefore, between applications of the various solutions was made as short as possible in the investigations in order to prevent the tick surviving and thus leaving the body of an infected host and further propagating the disease. The problem of killing all parasites upon a beast every few days without involving the beast itself in danger by direct or cumulative effect of the repeated applications, proved a difficult question. Arsenic, which is the chief constituent of most of the dips, is a strong irritant to the skin, and in addition is capable of occasionally storing up or accumulating its poisonous properties and suddenly exerting such in the form of acute arsenical poisoning.

The desirability of frequent cleansing of animals at short intervals led to the interval of four clear days (i.e. every fifth day) being determined upon as the shortest practicable time to which such interval could be brought with due regard to the safety of the beast and the destruction of ticks. This minimum time of four clear days was, however, found to be too severe a test for the majority of the preparations under examination to conform to. This difficulty led to the attempt to produce a dip suitable for use every five days without injuring the animals; this has now come to be known as the "Laboratory Dip". This dip has been well tested, and cattle have been put through the solution for sixty days at regular intervals of four clear days, the ticks being destroyed and the cattle maintaining their usual health. Furthermore, as far as Mr. Pitchford has been able to judge, cattle can be worked with safety directly after dipping in this "Laboratory Dip".

The only dip besides the "Laboratory Dip" which came before Mr. Pitchford's notice as being capable of frequent, safe and satisfactory application even to working oxen, was that used upon the Nel's Rust Estate (Natal). This dipping fluid is a modification of the Queensland dipping formula.

No attempt was made to compare the cost of the various preparations or to judge of the same from any preferential standpoint. All that was attempted was to ascertain the tick-killing properties of the preparation in question and the safety with which applications of the same could be made.

*Second Report.*—The second of Mr. Pitchford's reports dealt more with the manner in which the effects of a dip are exerted both upon the animal economy and upon the tick itself. More particularly, the observations recorded were designed to prove that the

advantages of the adoption of a short-interval system of dipping are not merely the advantages to be expected from a more frequent immersion of the beast and the more frequent "mechanical" killing of the ticks upon its body by such immersion, but also the advantages of the striking secondary results which are found to attend the adoption of short-interval dipping. These secondary results appear to be of the nature of an habituation or tolerance of the tissues of the animal to the presence of arsenic. "The effects from these frequent dippings appear to accumulate within the animal's system, producing as they accumulate a corresponding degree of tolerance or habituation on the part of the animal, the deeper layers of whose skin gradually become temporarily charged so to speak with arsenic so as to render the beast poisonous to any ticks which may become attached in the intervals between the dippings." The excretion or throwing off from the system of the accumulated arsenic is, however, a rapid one, and it is only by the short-interval dipping or spraying that this loss can be compensated, if the animal is to be maintained in its maximum tick-killing condition; dipping at intervals of ten days or a fortnight means that the animal simply acts as the vehicle by which ticks are collected and conveyed to the dipping tank, there to be killed by submersion in an arsenical fluid. Gradual habituation is, however, necessary, but tolerance becomes rapidly established, and a few weeks only are necessary to accustom an animal to submersion in the "Laboratory Dip" every five days without any discomfort. It appears, however, to be some time after this point has been attained before the maximum degree of tick-killing capacity is reached, when the animal appears to be incapable of further accommodation, having reached a point, so to speak, of saturation. This accumulation of arsenic is observed to be not a mere mechanical deposition or passive soaking, but rather a vital and active process; and the observation is further borne out by the fact that any arsenic in excess of the maximum content is eliminated from the skin, the elimination taking place through absorption by the blood-vessels which are contained in its deeper layers, such excess of arsenic appearing shortly afterwards in the urine. When it is considered that it is into this deep layer of the skin that the tick thrusts its mouth parts and obtains its nourishment, the significance of being able to establish and maintain a supply of arsenic at such a point of attack is seen. It must be understood that it is not the circulating blood that is poisonous to the tick; destruction is effected by strictly local influences, and consequently the practical point which Mr. Pitchford emphasises is that all parts of an animal to which ticks can gain access must be subjected to the thorough application of the arsenical solution at short intervals. If this point is not observed, regions of the body will remain open to attack, and may prove the one small vulnerable point of attack, through which infection may become established. It has been observed that, of cattle put through dipping tanks, completely effectual immersions will not, as a rule, be found in much more than 80 per cent. of the animals. "These points," Mr. Pitchford remarks, "should be remembered in routine dipping, otherwise areas of skin, such as the root of the tail or the inner ear (which are actual 'predilection sites' for the tick) will permit escape of the ticks there attached, and prevent the establishment of any habituation of the tissues at such spots. The smearing or hand dressing of these parts by oily preparations is a useful procedure, so far as it acts as a deterrent to tick approach, but if the protection of the animal is to be made as complete as possible such measures should not be made to supersede the application of the dipping fluid itself to the parts in question. If this thorough application of an arsenical solution to all parts is ensured, either by spraying or effectual dipping (or a combination of both processes easy of application), it will be found that the need for special oily dressings, etc., will be, in a great measure, done away with."

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## PART III.

PREVIOUS reports on the above subject have been designed to urge the adoption of the principle of a system of dipping at a shorter interval than usually practised, and also to pass in review the various existing proprietary dipping mixtures with a view to ascertaining their suitability for frequent application.

Our knowledge of the disease East Coast fever and of the life history of the brown tick—the chief transmitter of the disease—shows clearly that if we are to make sure of destroying the tick—and with it its infectious germ—we must attack it during the brief space that it spends engorging itself upon the blood of its host, the ox, and if we fail to ensure its destruction during this brief interval it will, by its survival, involve us in the risk of the perpetuation and extension

of the disease. If, therefore, we are to make sure that no tick is to survive which once gains access to its host, our destructive attacks must be so timed as to leave no interval during which a tick may engorge itself and—potent for future mischief—leave the body of its host.

When we learn that a brown tick may complete one of its periods of attachment to its host in so short a period as three days, or even less, we shall see that our attacks (if we are to cut off all possibilities of escape) must be at correspondingly short intervals.

Fortunately, it happens that this minimum period of attachment is rarely found to obtain the time of the stay of the immature forms of the brown tick (the larvae and nymphs) being generally several days longer than above, a tenure which brings them within the destructive effects of the recently devised system of short-interval dipping. The repressive influence of the short-interval or "five-day dipping" upon farms where disease has appeared has been amply demonstrated in the past, such instances being in strong contrast to cases where reliance has been placed upon the usual system of dipping at intervals of ten days or a fortnight.

Even where the short-interval system has been practised, cases of infection sometimes continue to occur from time to time under conditions and in places where no question exists of reinfection or reintroduction of the disease from outside. Such instances prove the possibility of the escape from an infected beast during the intervals between dippings of a certain number of ticks, and these ticks have served to keep alive and re-establish the infection after a lapse of many weeks or even months. Such outbreaks or reappearances of the disease are rare where the system of frequent dipping has become thoroughly established, for in such a case the possibility of the survival of the tick is decreased by reason of the "residual" or continued destructive effect exerted by cattle which have been frequently dipped, an effect which, while not always proving immediately fatal, is still frequently able to prevent the moulting of the tick and the arrest of its infectivity. This point, which was dealt with fully in Part II of this Report, will again be reverted to below.

The possibility of the disease being thus able in certain cases, in spite of the short-interval dipping, to reappear in a herd from which it seemed to have been eradicated, and the public inconvenience and private disappointment caused by such reappearance, led to the undertaking of the present work, in the hope that some system might be devised which would not only abolish this risk of recrudescence or reappearance of the disease, but would furnish a system by which its progress through a district or farm could be successfully opposed, or its ravages at least reduced to a minimum.

The main step in the solving of this problem was obviously the adjustment, if possible, of the principle of dipping to the life history of the tick, so that practically no chance should exist of any tick leaving its host, however short its stay, in a live (or uninjured) condition; but in order to adjust this point with exactitude it first became necessary to observe (by trial on a practical and ample scale) exactly when the danger of such escape commenced, a point of time which, of course, coincided with the shortest length of time spent by the tick on the body of its host. Reference to Schedule I will show how this point was determined, and the reason for deciling that a period of seventy-two hours (or three days) was the longest interval

which an animal could be allowed with safety to remain in undisturbed possession of its ticks.

The prospect, however, did not seem promising of being able, not only to adopt a 72-hour period of dipping with safety, but also under such a system to maintain indefinitely from month to month without loss of condition the animal subjected to the process. The reader who is sufficiently interested as to the detailed steps by which this point was arranged may refer to the schedules. Here he will see that the successful adjustment of the composition of the dipping fluid was not arrived at without some trouble in the endeavour to ensure (*a*) *Safety in use* (Schedule II), *and* (*b*) *Destructive effect on the tick* (Schedules IV and V).

These two cardinal points of safety and efficiency depended mainly, but not entirely, upon the adjustment of the arsenical content of the dipping fluid. Previous experiments had shown (see Part I of this Report) the method by which that essential ingredient, the arsenic, in a dipping fluid could be so adjusted as to give the maximum tick-killing effect with the minimum inconvenience to the beast itself, and this efficient arsenical percentage was shown to vary with and depend upon the intervals elapsing between dippings, a very high percentage of arsenic being tolerated where the dippings were separated by a period of some weeks. Where, however, it was found necessary to decrease the interval, i.e. increase the number of dippings in order to meet the problem of the destruction of tick life in all its phases, it became also necessary to greatly reduce the percentage of arsenic in order to avoid damage to the beast. Fortunately it was found that such reduction could be made without materially interfering with the poisonous effect upon the tick itself. In this way the composition of the old forms of dip which often contained as much as 5 lb. of arsenite of soda to 100 gallons (for monthly use) was reduced, in the "Laboratory dip", to 2 lb. per 100 gallons, a fluid which was found capable of application every five days.

This result seemed to comprise the shortest interval at which immersion in an arsenical fluid could be safely and effectively undertaken, and the wide adoption of this so-called "Short-interval dipping", as stated above, fully justified itself both by the restraint of tick life following its adoption and the undoubted check which it has exerted upon the spread of the disease East Coast fever.

As a regular procedure in the clearing up of a farm from its ticks, and in the absence of East Coast fever it was recognized at the time that so short an interval as five days would add materially to the routine trouble of farm life and make a considerable call upon the time, if not the purse, of the stockowner. Where, however, the possibility of the advance of East Coast fever had to be encountered, it was thought that no interval would be likely to be deemed too short, or trouble too great, if it increased the chance of ultimate escape. An extra inducement was also held out to the progressive farmer to adopt the stort-interval system by showing that in so doing he would gradually render the poisonous effect of his more frequent dippings continuous from one immersion to another by reason of the accumulated or "residual" effect to be secured by such frequent immersion, thereby greatly facilitating the rapid clearing up of the farm besides this increased prospect of holding in check the infection should it become introduced. Such considerations taken together would, it was thought, fully warrant the adoption of the short-interval

system, which, though somewhat irksome in its routine application, held out thus the prospect of a double ultimate advantage.

The fact is mentioned above that modified outbreaks continue in some cases to occur on farms where this process has been in use, showing the occasional escape of some forms of tick life from their infected host in spite both of short-interval dipping and its accumulated effect.

Our knowledge of the brown tick and its agency in the spread of the disease shows us that in such recurring outbreaks only the larval and nymphal forms of the insect could (after their escape from a sick beast and after moulting) be concerned in the production of future infection.

It is therefore obviously against the larva and nymph that our offensive measures must be directed in the endeavour to prevent their future development into forms in which they may become capable of spreading the infection.

As has been shown in Schedule I, the period of stay of these possibly dangerous immature forms upon a beast has been found to be as short as three days, a point which has been demonstrated by previous observers. The above-mentioned schedule shows, however, the possibility of larvae and nymphs maturing and leaving their host even before the expiration of this period of seventy-two hours, seventy hours, sixty-eight hours, or even less, sufficing in some cases to permit of escape and the possibility, if infected, of transference of the disease.

Even the shortened interval of a three-day dipping system, therefore, would appear to be inadequate to guard against all the possibilities of spread of the disease, and it would seem that even such readjusted dipping measures must fail by a few hours in ensuring certainty of result.

Fortunately, however, we are able to cut off all chance of escape by preventing the attachment of the immature tick for its full period of seventy-two hours or even sixty-eight hours. Reference to Schedule VI will show that, while the adult and hungry tick will attach itself readily to the newly-dipped beast, both the larval and nymphal forms are deterred from biting for a period of at least some hours, an effect probably due to the paraffin present in the composition of the dip. The exact period of this revulsion or deterrent effect was not determined with exactness, but it is of such a length as to amply cover the three or four hours of the seventy-two hours' interval which the dipping leaves unguarded. Proof of this fact will be found in the experiment described later in paddocks D and E, where the infection of these paddocks must have been inevitable had the innumerable nymphs and larvae present been able, in even a single instance, to use the whole interval of seventy-two hours for the purpose of their development, and so effect their escape, as in the case of the early-maturing ticks in Schedule VI.

The destruction by the system of five-day dipping of all *adult* ticks should be certain, owing to the length of time they remain attached to their host, a period which will ensure a second immersion in cases where attachment persists. Where, however, the period of attachment, as in the case of the larva and nymph, may be so short as to permit engorgement and escape between one five-day dipping and another, the problem is obviously only to be met as suggested above by the adjustment of the dipping process to an interval which will render such escape impossible.

In view of the fact that the percentage of arsenic requisite to produce a destructive effect upon the tick had already been adjusted with some nicety it did not seem at first hopeful that this percentage could be very materially reduced) so as to permit of a still shorter interval being adopted) without effecting the efficiency or tick-killing power of the dip.

Fortunately, however, it happens that the larvae and the nymphs—the forms of tick life which we are particularly interested in destroying—will succumb when exposed to an arsenical solution considerably weaker than that necessary to ensure the death of the adult tick, a fact which seemed to render it possible, without detriment to the host, to reduce the interval between dipping so as to ensure the destruction of all larvae and nymphs, however short their stay. If this could be effected, the completeness of the destruction by one dipping of all the adult forms attached to the host might for the following reasons be viewed with comparative unconcern.

The adult female will, before becoming completely engorged, remain attached a considerable length of time and so be subjected to two or even three dippings before being ready to leave its host. How rarely after one dipping such female forms remain on their host uninjured and go on to full distension, may be judged from the fact that out of over 10,000 adult ticks actually counted throughout these observations on cattle being subjected to the new process only 69 partially distended females have been found.

Careful detachment of these distended ticks, and observation under favourable conditions, shows that, in the majority of cases, the dipping arrests the process of egg-laying, while of those eggs which are laid only a small percentage are capable of subsequently hatching out.

Where two immersions in the dip had been experienced by the distended tick none of the eggs hatched, while only about 2 per cent. of such ticks were able to lay at all, and this to an imperfect extent.

As, however, the laying and hatching of the eggs of the brown tick is without significance—in so far as the transmission of East Coast fever is concerned—the escape of an occasional female form from the effect of the dip is a point of no interest, except perhaps to the farmer who is seriously undertaking the eradication of all forms of tick life from his farm (and in such a case reference to Schedule III will show the small degree of importance to be attached to such escape).

The paddock referred to in this Schedule III (to which future reference will be made) furnishes a practical confirmation of the above assertion, for in this experiment had any appreciable and regular escape of distended ticks taken place from the herd grazing this paddock, no such striking diminution of the tick life on this ground could have been looked for or experienced. There remains then the consideration of the importance of the other adults after attachment to their host, viz., adult males and adult but unengorged females.

To these forms not even the slight significance can be attached which we accord to the distended female. It is of course true that such ticks may produce the disease if they have passed their nymphal stage upon a sick beast. But—as previous observers have shown—with such attachment their power for mischief ceases, nor are they able, even should they resist the effect of the dip, to keep alive further infection of the veld, a point of importance in the repression of the disease.

The actual lethal effect of the newly-arranged dip upon these mature forms is shown in Schedule IV. It will be seen that an average of 70 per cent. are killed by the one immersion in the interval of seventy-two hours before the repetition of the dip, while the remaining 30 per cent. succumb before the next dipping is due, within a period altogether of six days.

A much more marked destructive effect can be obtained by the repetition of the dipping process at intervals of forty-eight hours (see Schedule V)—a perfectly practicable procedure with the dip-fluid which is noticed below—but there is no valid reason for hastening the killing of these adult forms in so far as East Coast fever is concerned.

While for the above reasons it will be seen that we need not arrange our dipping fluid so as to kill rapidly all adult ticks (for as we have shown not only are they negligible but their destruction is ultimately assured), it will be of the utmost moment for us to catch the elusive nymph and larva which, by escape, may maintain alive the infection of the veld. This result, fortunately, we are able to accomplish by lowering the strength of our dip (without lowering its essential efficiency) so as to permit of as frequent a dipping as will ensure the immersion of every tick—large or small—once attaching itself to a beast.

In the "three-day" dip the arsenical strength has been lowered until only one pound of arsenite of soda (of a standard strength of 80 per cent. arsenic trioxide) is used in the preparation of 100 gallons of fluid (a reduction in the arsenical content as compared with the previous Laboratory dip* of 53.5 per cent.).

This fluid—weak though it is in its essential constituent—is capable of fully meeting the two cardinal requirements mentioned above, viz., efficiency in tick destruction and safety in repeated use.

In the composition of this dip both the soft soap and the paraffin have been retained as necessary.

Endeavours have been made in certain quarters to do without these ingredients in the "Laboratory dip" and use a simple solution of arsenite of soda in the dipping tank. Part I of this report showed that the use of arsenite of soda alone was investigated and abandoned as being too caustic in its effect upon the skin for short-interval dipping. Reference to Schedules II and V of the present report will also give details as to the use of an arsenical dip at short intervals without the addition of soap and paraffin. It will be seen from the table that not only was it impracticable to use the arsenite solution alone (by reason of its irritating nature), but, further, that it failed to kill the ticks brought into contact with it as efficiently as the complete formula.

It is essential then for the purposes of the present short-interval dipping system that no alteration be made in the composition of the dip if the two points insisted upon above, viz., safety and efficiency, are to be assured.

While it will be found that the formula given (the exact manner of compounding and mixing of which will be found in Schedule VII) will be efficient in its general results, there is one part of the body—the ear—which calls for special treatment. By using the old Laboratory formula the ears were effectively cleaned, provided care was taken to

* The new fluid contains only ·08 per cent. of arsenic trioxide as against ·17 per cent. in the original Laboratory dip.

ensure the entrance of the fluid by complete submersion of the head. Where however the more diluted dip is used it is found that occasional nymphal ticks can survive the process if they have begun to swell or engorge before the dipping takes place. Only such ticks however as have attached themselves far down the meatus or passage of the ear appear thus to occasionally survive. The removal of the ear of a dead and tick-infested beast close to the skull will show in some cases numerous nymphs attached to the wall of the passage capable apparently of completing their engorgement in that position and escaping in due course to complete their life cycle as adults.

Probably the inaccessibility of such a region, together with the fact that the narrowing walls of the passage are coated with a waxy substance (cerumen) tends to prevent the penetration or efficient contact of the dipping fluid, and where this latter—as in the dip in question—is of low arsenical strength, ticks in such a situation may well survive the ordeal of one or even two immersions.

Although none of the engorged nymphs removed from this situation after dipping or spraying have proved able to moult, the fact that many survived for a considerable period points to this spot as a weak one in our defences. It was therefore determined to undertake the separate treatment of the ears, a procedure which, though increasing the routine trouble, seemed to render assurance doubly sure.

The chief difficulty encountered in this routine swabbing of the ears was the fact that the delicate lining membrane of the auditory canal would not tolerate the necessary frequent application of any preparation of an irritant nature. The usual coal-tar derivatives mixed with grease (a compound widely used for this purpose in the past) had to be abandoned in favour of something easily obtainable, as cheap, and less irritating. This desired material was found in due course and, after extended trial, has given excellent results, killing all forms of ticks with rapidity and certainty and not producing any irritation of the lining membrane of the ear however frequently applied. The homely character of the prescription and its ready availability will not be found to detract from its usefulness. Details of preparation will be found in Schedule VIII.

It now remains to show the results given by the above preparations in the practical tests of prevention and suppression of East Coast fever, and also in the eradication of tick life from infested areas.

At the end of this report will be found a map or diagram showing the sub-division into paddocks of a portion of the town lands* of Maritzburg. (See Schedule IX.)

These paddocks—which comprise a considerable area—are of varying shape determined by the purpose for which they were constructed and to some extent also by the contour of the ground. The northern or top boundary is some 750 feet higher than the southern fence along the banks of the spruit. Several wooded kloofs run north and south and divide this area, while along the lower grounds a good

* The accommodation at the laboratory for a work of this nature being quite inadequate, the Corporation of Pietermaritzburg was approached and, the requirements of the case being explained, permission was asked for the use of as much as was found necessary of the town lands contiguous to the laboratory for the purpose of carrying on this experimental work on an extended scale. It is with much pleasure that I am able to acknowledge the ready sanction which was accorded to the request, and it is due in no small measure to this helpful attitude on the part of the municipal authorities that the following observations were able to be undertaken and thus recorded.

deal of marshy ground exists. The vegetation along the southern part of the paddock marked A is very dense, while most of the paddocks have considerable stretches of old (last year's) grass.

It will thus be seen that the ground chosen presented features representative of an average farm as regards tick habitat, differences in elevation, etc.

In Schedule IX (map) it will be noticed that certain of these paddocks are surrounded by double lines of fence. This double fencing was undertaken chiefly to ensure the isolation of such paddocks from adjoining ones as well as to provide means of access. In the paddocks B, D, E, T, H, and F, active infection existed, and it was part of the scheme of experimental work to demonstrate or disprove the possibility of the extension of the disease by what might be called natural means, i.e. the crawling of infected ticks from one enclosure to another. The distance between these double lines of fence was determined on after a preliminary experiment, undertaken to show the actual distance travelled by the most active form of tick life—the hungry adult. The results of this experiment will be seen in Schedule X in which a diagrammatic representation of the distance and rate of travel is shown. The schedule shows, that of 770 active hungry ticks the furthest migration noted was twenty yards, the great majority coming to an apparently permanent rest within half this distance from the liberation point.

In placing the distance at thirty yards therefore as the interval for the double fences it was thought a safe margin was allowed, the correctness of which opinion was borne out subsequently as no case of the transmission of the infection from any one paddock to another has occurred across this space (a point which will be noticed below in speaking of the means of transference of the infection).

Provision for isolation by distance having been as far as possible made, the fences as shown in the map were erected so plotting out the area into spaces approximately of the shape shown. Each of these paddocks designedly enclosed certain patches or strips of old grass, but the greater part of each of the enclosures comprised good growing grass which rendered artificial feeding unnecessary throughout, experiments lasting approximately from September, 1910, to the end of March, 1911.

A good number of ticks existed upon the ground thus enclosed, a number which can be approximately judged by the average daily number picked up by the herd when commencing to graze paddock A (see Schedule XII).

In paddocks D and E, however, it was the intention to ensure a degree of tick infestment as gross as possible, and for this purpose the hatching of tick eggs was arranged on a large scale so as to ensure the liberation of some millions of larvae of the brown tick. Distended females were collected in numbers and placed in many large flat glass jars (about thirty-five in each vessel) and kept in the Laboratory buildings. The average number of eggs laid was about *6000 per brown tick. When the eggs commenced to hatch the glasses containing them were uncovered and placed in the midst of patches of long

* These numbers were computed by weight—a sufficiently accurate method for the purpose in hand, the average weight of 100 Brown tick eggs is about 5 milligrammes, a single egg weighing ·05 milligrammes, or approximately 1,000,000 eggs to 1 ounce. Larval ticks shortly after hatching were found to weigh ·0026 grammes per 100 approximately, a weight of only about half a grain to 1000 ticks.

grass under proper shelters to keep off direct sun and rain. A gross infestment of the veld was thus ensured, the ticks rapidly attaching themselves and going through their various stages on the cattle running in the paddocks so infested.

In this way the natural condition of a grossly infested veld was simulated as closely as possible, and the cattle in these paddocks (D and E) were maintained under conditions of infestment—without restraint by dipping—such as they would experience if grazing naturally on badly tick-infested veld.

The main intention of this experiment was—by the adoption of the "three-day" dipping—to prove the possibility of introducing beasts suffering from the disease East Coast fever into such paddocks (amongst healthy animals and amidst countless ticks) without incurring the risk of spreading the disease or contaminating the veld.

All the elements of a fierce outbreak would thus be assembled together and the introduction of a single infectious tick would probably prove the spark producing the conflagration.

Before, however, this critical experiment—which by failure would involve the loss of a number of cattle—was undertaken preliminary experiments were decided upon. These "limited liability" experiments were undertaken with the object of determining whether a tick-infested sick beast is able to contaminate the ground upon which it stands if it is sprayed at intervals of seventy-two hours. Such preliminary experiments were carried out as follows:—Two beasts were infected with East Coast fever (by turning them into a small infected experimental paddock kept for the purpose of producing the disease when necessary). As soon as these animals reacted they were removed from this paddock, sprayed with the three-day dip and tied up for several days (until free from ticks and until the specific organisms appeared in their blood and gland juice). They were then taken to certain spots in paddock H (see map, spots marked with a * distant at least 50 yards from each other) and were there picketted and at once infested with numbers of brown ticks in all stages of development. The area of ground therefore which would become contaminated by falling ticks would be at first limited to the circle described by an animal in walking round its picket peg.

At noon upon the 4th day (seventy-two hours) after being placed on these spots the animals were removed to a little distance and again sprayed with the three-day dipping fluid. Here they were allowed to stand for an hour and were then removed to two fresh sites and again picketted, while the neighbourhood of each original spot of occupation was at once fenced in. After a further lapse of three days the procedure was repeated, the beasts being removed and sprayed and the spot upon which they had stood enclosed.

The disease usually proving fatal on the third spot thus occupied the carcass of the animal was skinned and removed, the hide being left where the animal died, a spot which was again fenced in.

The above experiment was then repeated on exactly the same lines, using two other infected animals to control the observation of the first, and reduce the risk of coincidence or insufficiency of data.

As a variation of the same experiment two further animals were taken and allowed to remain in the infection paddock until they showed the organism in their system and were heavily infested with ticks. They were then sprayed as usual but no time was allowed for the beast to become cleaned of its numerous ticks. In this condition.

while grossly infested with all forms of tick, both mature and immature, they were pegged out on plots in paddock H with the above cases, and were treated in a similar manner to them, being sprayed and removed to fresh ground every three days as long as life lasted.

After the various enclosures (at distances of 50 yards from each other) upon which these animals had been confined and died, had remained closed up for a minimum period of one month, they were opened and a healthy beast was placed within each enclosure.

The object of the above preliminary experiment therefore was to secure an answer to the question:—

Can a sick and tick-infested beast convey the disease or contaminate the veld if sprayed every seventy-two hours with the three-day dip?

It is obvious that if any ticks had been able to escape unharmed after feeding on these sick beasts, the ground or plot upon which the latter were tied and its immediate neighbourhood would in due time become dangerous to a healthy beast subsequently confined upon the same plot.

1. Thus if no appearance of the disease took place on those plots first occupied by animals which were brought on to the ground sick but free from ticks (and were then infested and allowed to remain unsprayed for a period of seventy-two hours) the conclusion is justified that no infectious forms could have had time to engorge and leave their host before the removal of the beast to the next plot.

2. Further, if the second plot of ground occupied by an infested and sick beast remained uninfective when healthy beasts were subsequently confined upon it, the inference would be justified that the spraying process undertaken when the beast left the first plot at the end of a seventy-two hours stay had sufficed to arrest the disease.

3. Similarly if no infection of the first or subsequent plots followed the presence of beasts placed there while not only sick *but harbouring all forms of ripe brown ticks*, it is obvious that the effect of the single spraying, given immediately before the occupation of the plots, sufficed to check the disease and prevent the development (though perhaps not the escape), not only of unfed ticks but of those already distended ticks on the point of leaving their host.*

The outcome of the above experiment was, briefly, that no disease developed on any of the plots where the test or control animals remained several months.

The question therefore was conclusively answered as to whether a sick beast (infested with ticks and harbouring organisms in his blood, etc.), could convey the disease or contaminate the veld if sprayed every seventy-two hours with the three-day dip fluid.

The final and controlling test was then hazarded under conditions as critical as possible. Paddocks D and E had been prepared as described, *ut. sup.*, and had been grazed for some months by a small troop of healthy cattle, ten in number (a number subsequently increased), which were intended for the purpose of another experiment (to be referred to below).

* In the case of engorged nymphs, which have received one spraying with or dipping in the three-day dip, the results are (as with the distended adult) not always immediately fatal. In many cases the normal period for moulting is greatly exceeded, and though life persists, examination of the interior of the nymph fails to show any evidence of the development within of the adult insect. Such a tick would, of course—however long it retained its vitality—be quite incapable of any further infective action.