As previously described, excessive tick infestment existed, and had been promoted, and into these paddocks were drafted all the sick cattle as they became available from another series of experiments undertaken to show the general means of conveyance of the disease.

The only precaution taken at first was the spraying of the sick beast, or, if strong enough to travel and climb, its immersion in the dip-tank before it was placed in either the paddocks in question (D and E). Later, when the importance of guarding against the survival of ticks in the deep ear passages was recognized, the ears of all sick animals were dressed with the mixture described in Schedule VIII.

This process of spraying was carried out every three days, the sick beast being brought just outside the paddock for the purpose and returned shortly after the spraying was concluded. This procedure was continued during the life of the animal, and its hide was finally left to be investigated by the healthy cattle in the paddock. In this way, extending over a period of three months, ten sick animals have been introduced into these paddocks and allowed to die there. The ticks of the paddock have readily attached themselves to the sick beasts during the seventy-two hour intervals between spraying, and, although ample time has elapsed, no single case of the disease has been produced, the healthy and heavily tick-invested cattle grazing with the sick beasts indiscriminately as long as the latter lived.

No sick beast was introduced into these paddocks until it showed positive microscopic evidences of suffering from the disease.

The dividing fence between the paddocks D and E erected for the purpose of another observation was maintained during the early part of the above experiment, as into the lower paddock E were introduced two sick beasts directly after spraying and while carrying ripe ticks in their coats. The stringency of this latter test and the possibility of its failure seemed to render it expedient to maintain the fence between the paddocks in order, in the event of failure, to prevent confusion in interpreting the exact causes and results, and to limit probable loss. Such fears, however, proving to be groundless, the double fence was removed, and the paddocks were made one.

Situated on the fringe of the advancing disease, with multitudes of ticks upon the farm, the outlook of the stockowner has hitherto been a black one.

He has been told that if he can eradicate the tick the disease will not appear, but the eradication of the tick has seemed to him an impracticable procedure, or only to be attained after years of consistent dipping, while the disease is at hand and menaces him from day to day.

Now, however, his case will be more hopeful for—provided the disease has not yet reached him and his farm is fenced and he is willing to undertake the small amount of extra trouble consequent upon the adoption of the system below—there seems in the writer's experience no reason why the danger should not either be averted entirely or reduced to quite insignificant proportions, while at the same time the rapid clearing of the farm from all forms of tick life (a problem dealt with below) will more than compensate for the trouble involved in the carrying out of the system recommended.

In dealing with farms already infected, the difficulty is greatly increased, particularly where large areas, perhaps imperfectly fenced, have become contaminated by ticks falling from sick beasts. Where,

however, the disease is known or supposed to be confined to paddocks of limited size the eradication of the disease under the new system of dipping is not so serious a problem as it has been considered in the past, provided an adequate number of sheep or horses are available for the purpose.

The following experiment was designed to show both the length of time and the effort necessary to ensure the clearing up of the infection on an enclosed area of limited extent. The paddock in question marked G on the map, had, during the progress of the work described in Part II of this Report, been used as an infection paddock, i.e. an enclosure into which cattle could be introduced in order to infect them or test their immunity. The paddock was not large, its length roughly being from 600 to 700 yards, and its breadth irregular. The grazing, however, was good, and tick life abundant. Although the infectious nature of this paddock was looked upon as beyond doubt, it was thought advisable before commencing the experiment to demonstrate this point to certainty, accordingly on 1st November, 1910, a beast (No. 114) was shut in this enclosure and allowed to roam. The taking of its temperature for the first time on 12th November disclosed the fact that it had already become infected with the disease to which it shortly after succumbed. On 17th November a troop of horses, donkeys, and mules (numbering nineteen altogether) was placed in the paddock. These animals were driven up every three days and passed through the dip, being brought along the left-hand path or drive shown in the map to avoid risk of contamination of the path by which beasts from uninfected paddocks approached the dip. Before dipping, the ticks in the mane and tail of each horse, etc., were carefully counted, a procedure which though taking much time, was made in order to gauge the decrease of the ticks in the paddock from week to week.

During the first two periods of grazing (of three days each) the numbers of ticks brought to the dip were excessive, but on 25th November (the time of the third dipping) the average per animal had fallen to seventy-five, while a month later (28th December) it had been reduced to an average of four and a half ticks per horse for the three days, from which point it fell slowly to an average of about one tick per animal per diem, around which point it remained for some time before further constant reduction was noted. These figures will serve to give an impression as to the rate at which we can effect decrease of tick life. (Observations on the more systematic clearing of larger areas are given below.)

The first effort to gauge the time at which this paddock lost its infectivity was made on 14th December, when the ticks were still numerous. On this date a beast, No. 104, was introduced and regular observations were made upon its temperature after the tenth day. No reaction occurring, even many days after the termination of the usual period of incubation, a further animal was introduced, and the temperature of this beast also remaining normal throughout a month's exposure four beasts were introduced (19th January); and as these showed no signs of contracting the infection a further batch of five animals was turned in on 17th February and remained healthy. The quarantine of the paddock was then raised and the whole ground grazed over by the main herd without a case of the disease occurring.

The horses which had been used for the clearing up of the paddock were removed about the middle of December. Their condition had

not suffered, nor had any signs of skin irritation been produced by their frequent immersion.

In reviewing this instance it would appear that the period of occupation by the horses—from the 17th of November till 14th December, the time the first beast was introduced, a period of less than a month—was sufficient to divest the paddock of its infection. Further observations tending to confim the above finding were then undertaken. It has been above mentioned that certain paddocks, amongst which were B, J, and F (*vide* Schedule IX), were infected i.e. contained beasts suffering from the disease. Such paddocks were used for various experiments (which will be referred to in their place), and at the conclusion of such experiments the grounds of these enclosures remained and were proved to be in a condition of active infection.

From such infective paddocks the danger was progressively removed by a method of systematic grazing and dipping—in the case of paddock B by sheep, and in J and F by the nineteen horses, etc., used in the clearing up of paddock G.

In certain observations on the modes of transmission of the disease referred to below it is shown that an effort was made to concentrate the infection against the outside fence of paddocks D and E.* When beasts became very sick in either of the enclosures B, J, and F they were, towards the last, herded on the west side of their paddock in order to ensure the concentration of the infection as far as possible on the east side of D and E.

As these experiments became concluded an endeavour was made to clear up the infection from these paddocks by the herding of horses and sheep upon the areas known to be most highly infective. After several days of such concentration the troop was permitted to graze generally over the whole paddock, bringing to the dip every three days all the ticks attaching to themselves in that period.

In this manner it was found that quite a short period sufficed to eradicate the disease, e.g. in paddock J the horses were turned in on 8th February (an interval of six days); they were withdrawn and two control beasts were placed there, and have remained there since in a healthy condition. Paddock F was similarly treated, and after ten days grazing was stocked in a similar manner with a like result. In paddock B a flock of 150 sheep† was employed. These were herded at first along the borders of paddock D, where the infection was likely to be grossest (proof of the existence of the infection on this ground will be found in the record of another experiment), and after ten days grazing on and about the locality they were withdrawn (having been subjected to the process of dipping every week) and their place taken by four head of cattle, which, like the other test cattle, have remained uninfected.

The above facts, therefore, are brought forward to show that the hope of cleaning up localities where the infection is known to be restricted is not so remote as it has been generally thought. It is not suggested, however, that such measures as these described above can be adopted on unfenced farms over which the disease has swept

* A small * serves to show the relative spot in these paddocks where some of the infected animals actually died and where their hides were left.

† The use of the dip for sheep is dealt with later on.

unrestrained. Where, however, the invading disease has been fought rationally by segregation paddocks and the prompt isolation of sick animals, it is thought some method of systematic (not promiscuous) grazing, combined with short-interval dipping, will be found to hold out a good prospect of early and complete eradication, helping thereby the release of farms from quarantine restrictions which would otherwise have to remain imposed for lengthy periods.

In considering the deductions to be made from the above eradication experiments, the writer is aware that results achieved over such limited grazing areas as those available for the purposes of the experiment cannot be applied too closely to the problem of cleaning up paddocks or areas of great extent if the whole extent of such latter is presumably contaminated by the unrestrained wanderings of beasts in a state of infection and infestment with ticks.

It seems, however, permissible to hope that the results will be found capable of application on farms and premises where the conditions are favourable and the question of eradication one of the utmost moment.

Large infected areas will naturally require a larger number of unsusceptible animals to effect disinfection. In such cases the attempt is certain to be attended by success provided consistent efforts with adequate numbers are made, and the ground systematically grazed as illustrated in Schedule XI.

Reference has been made above to experiments having for their object the demonstration of the means by which ticks are conveyed and the disease East Coast fever is spread.

Various theories have been brought forward to account for the transmission of the disease from one locality to another. Men, animals, birds, vermin, hides, etc., have all been suggested as probable factors in the spread of the disease. Such conjectures, however, have not received, so far as the writer knows, the confirmation to be obtained only by observation under critical conditions.

It therefore seemed expedient to attempt the proof of some of the more prevalent opinions in order that, if proving fallacious, inconvenience and unnecessary restrictions might be avoided, while, if confirmed, increased care and more intelligent precautionary measures might be adopted.

Before, however, attempting the solution of the question of the spread of the disease by agents such as above it seemed desirable to inquire into some of the conditions governing the spread of the infection in its usual and more natural progress.

Reference to the map will show that paddock D is separated from the infectious paddock B by a single line of fence, while paddock E is surrounded on all its sides by a double fence. Around all the sides of both these paddocks wire netting (3 feet high and of $\frac{1}{2}$-inch mesh) was placed with the intention of arresting the passage into them of ground vermin (rats, rabbits, etc.) from the infectious enclosures B, J, and F. Early in November these paddocks D and E were stocked with ten head of cattle, and it has already been stated how the infestment of these enclosures with ticks was secured. Active infection had been introduced on 28th October into the contagious paddocks B, J, and F, and the disease concentrated as far as possible by herding sick animals close to the western fence of these paddocks. Several beasts actually died along this fence line during the early days of

November, and their tick-infested hides were allowed to remain upon the spot.*

From the evidence afforded by entomological reports and by the results of the tests as to rate of engorgement, moulting, etc., given in Schedule I, infectious ticks could be expected to be present along this fence line towards the end of the month of November, and—provided the alley-way or division between the paddocks of 30 yards was insufficient—might be expected to make their presence obvious in paddock E some two or three weeks later, as no obstacle greater than a half-inch netting would oppose their entrance.

In paddock D, which was singly fenced, the eastern side of the fence line ran through a belt of last year's grass. A passage 6 feet wide was cut in this grass along the outside of the fence, i.e. in paddock B, and three sick beasts were picketted in the long grass at such a distance that, although they could not encroach upon this passage-way, they were within a few feet of it when at the full length of their short picket rope. These beasts were heavily infested with brown ticks in all stages, and they succumbed early in November.

The lower part of the paddock was then shut up to prevent possibility of artificial or inadvertent conveyance of ticks by men or animals from the long grass in B across the 6-foot pathway into D. In this case the distance barrier of 30 yards was absent, and the only defensive measure consisted of a passage 6 feet wide between the long grass in one paddock and that in the other.

The result of the above experiment is that no extension of the disease has occurred in either of the paddocks in spite of the fact that the grass on the outside of the fence was in a condition of virulent infection, a fact which later observations, *q.v.*, proved.

The preliminary experiments designed to lead up to the above critical tests should be borne in mind when attempting to review the significance of the final result. Schedule X shows the maximum distance likely to be travelled by the average hungry adult tick, and it is a fair inference that the immunity of paddock E was due to the establishment of the neutral zone of 30 yards.

Reference to the same schedule will also show the striking defensive effect which even a narrow strip of old grass will provide against tick advance. A month after the deaths of the animals in paddock B the edge of the strip of long grass showed many ticks visible, a much grosser state of infestment than existed elsewhere in this paddock. Frequent and exhaustive search was made, with due precautions, along the strip of closely-cut grass, but no tick was at any time discovered. It is evident therefore from the negative final result the infection was unable to spread from the edge of the long grass by reason of the unprogressive character of the tick.

The utility of the belt of old grass—as illustrated in the schedule and in the foregoing experiment—as a defensive screen should therefore be borne in mind, as it may possibly add to the resources of stock-owners who are eager to adopt every known means to check the advance of the disease from any recognized focus of infection.

The above observations may be considered as comprising in part the natural means of spread of the disease and its check or limitation under normal conditions. Practical observations, however, have

* These animals were, of course, not dipped or sprayed at any time.

shown the tendency of the disease to travel long distances in a manner quite inconsistent with the gradual and progressive invasion likely to be caused by a slowly-creeping insect such as the tick. These outbreaks clearly show the existence of some tick-transporting agency capable of carrying the carriers, and distributing them far distant from original foci of infection. With a view to determining with certainty some of these agencies of transmission the following experiments were made:—

Human clothing has long been under suspicion of mechanically carrying the disease from one spot to another.

In a country such as this where native pedestrians travel long distances, passing perhaps through many farms in the course of a single journey, and not always confining themselves to well-defined roads, etc., the agency of the native as an unintentional factor in the spread of the disease has long been suspected.

The following experiment confirms this suspicion:—

Paddock J (*q.v.*), in shape a parallelogram, barely 100 yards in breadth, was intentionally constructed to prove the point in question. It is isolated on all sides from risk of transfer of disease from contiguous paddocks by the double fence described before. About the middle of November two beasts (Nos. 105 and 106) were placed in this paddock, which was then permanently closed, the only access being by two stiles, one at either end. The disease had been previously introduced into paddocks B and F, and two animals had died at the commencement of November in the long grass at the upper portion of paddock F.

On 30th December (six weeks after the death of the first animal in paddock F) four natives were caused to walk directly through paddock F along an old kaffir path* and climbing the stile leading into paddock J, to walk through this enclosure into B, and then to return by the same route to F.

On 4th January this procedure with two natives was again adopted, and again on 10th January, the men passing straight through paddock J and returning again to F.

On 17th January the evening temperature of one of the test animals was 104.3, and death from typical East Coast fever occurred sixteen days later. The other animal contracted the disease a short time afterwards.

It is probable the infection was established by the first traversing of the paddock on 30th December, which, allowing a few days for the adult tick to find its host, would give a period of incubation of about fourteen days. The fact that no ticks were seen to attach themselves to the clothes or persons of the natives on this date cannot be considered satisfactory proof of their absence, as subsequent experiment tends to prove.

The appearance of the disease so promptly after the breaking of the quarantine is striking evidence as to the risk of conveyance of the infection which is incurred by unrestricted foot traffic through an infected area.

The conditions under which the experiment was conducted were of course exactly those which might be expected to lead to the conveyance of the disease, and it might be objected that such ideal

* This kafir path—shown on Map A by a dotted line—had been intentionally enclosed in the paddock for the purposes of the experiment.

conditions of spread rarely, if ever, exist in actual experience, or at any rate to an equal degree. While this of course is recognized it will be remembered that the point to be decided with exactitude was the possibility or otherwise of the spread of the disease by means of pedestrians, a theory which now must be considered as having passed from conjecture to certainty.

Equally striking confirmation attended the endeavour to prove the agency of infested hay in the production of the disease. Long grass from paddock B was cut from a patch of about 50 yards in extent. This grass was cut with sickles and well shaken and examined in the process. After drying it was stacked, and appeared after close observation to contain no signs of tick life. The material was used as bedding for two healthy animals confined in a small enclosure provided with a shed, which had been erected on clean or uninfected ground. This bedding was first used on 6th February, and thirteen days after its use had been commenced one of the beasts commenced to react, and in due course died from the disease. The other beast was at once withdrawn and sprayed.

In this way the theory of the possibility of transmission of the disease by the medium of hay was brought to proof under exact conditions of observation. Whether hay becomes divested of its tick life by longer keeping is a point not as yet determined, as far as the writer knows. The preliminary experiments with ticks, as given in Schedule X, prove that these insects are capable not only of concealing themselves skilfully in the axils of the leaves, etc., of grasses, etc., but also that, once established on a certain tuft or stem of grass, their tenancy is very persistent. Doubtless lengthy storage would divest hay of its dangerous properties, but in the absence of exact knowledge as to duration of tick life under such conditions it would seem inadvisable, whatever its age to use—either for feeding, bedding or packing purposes—any hay drawn from a spot or locality under suspicion.

While the above agencies (viz., human traffic and hay) have been looked upon as such probable factors in the transmission of the disease as hardly to need scientific proof, the theory of the agency of animals, especially sheep, has been more open to question, no direct evidence—so far as the writer knows—having been brought forward in support of the suspicion. The question must, in the light of the following experiment, be considered as definitely decided.

A small flock of twenty-five sheep was turned into paddock B and herded in its lower part. At night they were folded in a small shed in paddock C. This shed was also used at night time by two beasts which had occupied this paddock for some three months. Ten days after the first entry of the sheep into this shed the disease broke out in paddock C. As no other agency could have been concerned in this appearance of the disease the conclusion is unavoidable that the infective tick attached itself during the day to the sheep grazing on contaminated ground, and that it was transferred in the sheep's fleece to the shed where the animals were folded at night, there leaving the sheep for attachment to its more congenial host, the ox. The agency of the sheep in this case would doubtless be that merely of a mechanical transporter of the tick, inasmuch as complete attachment would have divested it of its infective power. The point which seems of significance is that ticks, which generally freely attach themselves to the sheep, are also capable of remaining unattached in

the fleece and of exercising some selective preference for their bovine host should the opportunity of transference present itself.

The movement of undipped flocks through clean farms or areas, or even from one paddock to another, must in the future be the subject, under certain conditions, of increased caution.

The hide of a beast dying from East Coast fever has always been an object of suspicion as regards its infective potentialities.

In order to confirm or disprove the theory a hide was removed from a beast dying during the night or early hours of the morning of 4th November. The animal, which showed a considerable degree of tick infestment and was of course undipped, was skinned about 8 a.m. and the hide laid, hair down, upon the grass in a clean enclosure. Three healthy beasts were then picketted at different points round the spot, and at such a distance that they could approach within 6 feet of the hide itself. They remained in these positions for seven weeks without contracting the disease, and were kept under observation for a period of fourteen days after their removal. No disease developed in any of these animals.

The intention of exposing the test animals shortly after the hide had been put in its place was to provide facility for the attachment of any ticks leaving the hide unengorged, or only slightly fed, and seeking reattachment to another host. The period of seven weeks during which the animals remained close to the spot was a sufficient period to have allowed of the moulting of any larval or nymphal forms of ticks remaining attached to the hide, and of their assuming an active and hungry stage. The fact that no infection followed such close contact would seem to prove that no such potentially infectious forms escaped from the hide, otherwise infection would appear to have been inevitable.

The writer's opinion is that all engorged or sufficiently fed larvae or nymphs left the hide at, or shortly after, the death of the beast,* and several hours before the removal of the skin, and that ticks which at the time of skinning remained attached or crawling were unable to mature owing to the absence of nutriment and possibly to the commencing drying of the skin. If this theory were correct it would appear that a process of natural " disinfection ", so to speak, occurs of the hide of a beast dying from the disease.

While it seems right to quote the results of the above negative experiment in reviewing the various factors which have been credited as agents in the dissemination of the disease, it seems that too much significance should not be attached to the results of the test, inasmuch as no accurate observations could be made in the case as to the exact time elapsing since death, it being conceivable that by the anticipation of a few hours a positive result might have been secured.

The experiment also (beyond adding something of a negative nature to our sum of knowledge concerning the disease and its means of spread) cannot claim any practical application to our systems of eradication or control, nor would it seem expedient to modify existing restrictions concerning the dipping, etc., of hides before removal. Such articles—apart from the question of any original inherent danger—must always be looked upon as an ideal medium for the carriage of ticks should the means for reinfestment be present, and the

* The hide was occasionally turned over, but no adhering ticks could be detected twenty-four hours after its exposure.

complete disinfection of the skin of the beast dying from East Coast fever must continue to be considered as of paramount importance.

Turning from the foregoing observations on the prevention, eradication, and means of spread of the disease East Coast fever, it may be of interest to quote certain observations undertaken in the endeavour to show the ease and rapidity with which paddocks of moderate size can be divested of their ticks, provided systematic and sustained efforts are made towards clearance under a system of short-interval dipping.

The extinction of the non-pathogenic or uninfected tick from large areas—or even its reduction within reasonable limits—has generally been looked upon as a well-nigh impossible task, or one only to be achieved by an irksome system of dipping extending over a period of some years.

The following experiment will show, however, that the end can be attained with certainty and rapidity provided the owner is prepared to take the necessary trouble. Schedule XI gives a rough ground plan of paddock A adjoining the paddocks shown on map 1. The extent of this enclosure is about ninety acres, its contour very irregular, and the vegetation at its lower part dense with much long rank grass.

This paddock which contained many ticks in its lower parts was roughly divided by pegging off (with fencing standards), the corners of squares having sides of about 200 yards in length. In certain parts the contour of the ground was such as to prevent the sub-division into rectangular figures, but the superficial area of such irregular divisions was roughly made to comprise the same extent of ground, viz., about eight acres to each plot. These plots or sub-divisions were numbered as shown in Schedule XI, and each plot was grazed for a period of three days by a small herd of cattle (about thirty-two in number).

At the expiration of the seventy-two hours grazing the herd was driven down and passed through the dip after a careful count had been made of the number of ticks present under the tail and in the brush. The beasts when dry were returned to the next plot and confined roughly within its limits during the day by two native herds, at night the cattle were at liberty to graze anywhere within the paddock.

In this manner a *systematic* grazing of the whole area of the paddock was ensured during the hours of daylight, a period which Schedule XII shows to be the most important time in consideration of some form of tick attack. After the three days grazing each plot remained unoccupied while the eleven remaining plots in their turn were being grazed—a period of about thirty-three days occurring from one occupation to the next.

In spite of their restricted grazing ground (or perhaps by reason of it) and in spite of their regular dipping every three days the herd remained in excellent condition, as the frontispiece to this report which was taken after their sixtieth dipping at seventy-two hours interval will serve to testify.

It will be seen that the numbered plots of Schedule XI enclose the dates upon which they were grazed, and the figures against these dates give the average of the number of ticks found upon the beasts and brought away from the plot to the dip. The decrease is interesting and shows in a marked manner the effect which one short period

of three days grazing will produce upon a given area and the consistent diminution in tick life brought about by each repetition of the process.

Any question as to the practical tick-killing properties of the three-day dipping fluid would be answered as directly by these results as by the restraint exercised on infected ticks in the foregoing paddock experiments.

It is of course remembered that the above results were attained during summer weather and while good grazing was available, and it is not thought that the exact details of the experiment could be applied without adjustment under all conditions of season and veld.

Like much of the foregoing work, however, the question of exact applicability to every condition has been less a matter of concern in this experiment than the establishment of standards of comparison which may serve—though applied under differing conditions—to guide those seeking to suppress the disease East Coast fever or eradicate the tick.

In the attempt to compute the actual efficiency—i.e. the extent of damage to the tick—of any dipping agent it must not be forgotten that the visible result (or the number of dead ticks found) is only a part of the actual effect produced (see Schedule V). This point was called attention to in Part II of this report where it was shown (Part II, page 8, Schedule B) that the effect of a dipping remained for several days after immersion, and that ticks which attached themselves during the persistence of this residual effect would—though undipped—succumb in large numbers if the dipping of their host had previously been carried out at short intervals in an arsenical solution of a strength properly adjusted to the interval of time between immersions.

In the endeavour to compute this residual effect in the case of the three-day dip a number of observations were made (see Schedule XIII) from which it will be seen that the effect—though still serviceable—is considerably less than where a dipping fluid of double the arsenical strength is used (as in the Laboratory dip). This diminution of the residual or sustained killing effect in the new dipping fluid seems at first a serious drawback until it is remembered that the need for such sustained effect is done away with almost entirely, no tick once attaching itself to the beast being able to escape immersion.

Where dipping is practised once every week the need for such prolonged action is more apparent, although, as stated above, instances must even here occur of ticks escaping and living to spread the disease.

Such cases, however—from the wide practical results secured—must be of rare occurrence only.

Reference to the Schedule XIII will show that the residual effect established by the use of the weakened dip is responsible for the death of 16.8 per cent. of the adult ticks attaching themselves in the short interval before the repetition of the dipping process.

A point of some interest coming to light in the above connection was the higher degree to which—under identical conditions—this sustained or residual effect became established in the case of the horse, in which animal the percentage was 22.5 per cent. or nearly 6 per cent. greater than in the case of the ox, such percentages being derived from 220 observations in the horse and 107 in the ox. The writer is at a loss to suggest an explanation for this unexpected result unless upon the assumption that the rate of elimination of the arsenic in the

layers of the skin is greater in the ox than in the horse. The existence, in any case, of a difference to the above degree would seem to point to the fact of some vital (physiological) difference in skin activity rather than a difference in capacity for mechanical absorption (under which theory the thicker skin of the ox would seem likely to prove more absorbent and more tolerant and be capable therefore of exerting a more pronounced residual effect).

The predilection of the brown tick for certain sites or regions of the body has often been noted by observers in the past, and the frequency with which ticks attach themselves to the extreme end of the tail, among the long hairs of the terminal tuft has led a number of farmers to remove this tuft with the intention of reducing the incidence of tick attack at this spot, it having been observed that if the hair at the end of the tail is removed the number of ticks found in this situation is considerably lessened.

It was desirable to observe—in view of the increasing prevalence of the custom of removing the tail tuft—whether any advantage really attended such removal. The disadvantage, from the animal's point of view, is obvious enough, especially in close warm weather when flies are troublesome, and unless the operation can be proved of utility its further adoption seems inexpedient.

Accordingly a series of tests was instituted in two small herds or lots of fifteen beasts each, both of which herds were grazed together under identical conditions. In one lot of cattle the hair was clipped from the tail, while in the other case the tails were left long and untouched. These two herds were brought to the dip every three days, and the occasion was used to count the numbers of ticks collected in this period by the two herds respectively. From the Schedule XIV it will be seen that the efficacy of the tail tuft as an agent for the collection of ticks is considerable, and that by its means 66 per cent. more ticks become actually attached to the long tailed beast than to the beast with the tuft of hair removed. This is a point of no small importance where an endeavour is being made to clear up tick-infested pastures, and it is evident that no good purpose is served by avoiding to a great degree the attachment of the insect, if by such avoidance more than a third of the ticks which should have been secured and brought to the dip are left behind to indefinitely continue the infestment of the ground.

It seems therefore that the practice of the removal of the tail tuft is one which should be discontinued in the interests both of the owner and his beast. At the same time the fact should be recognized that the hairs of the long tail serve to some extent as a defence to the tick against the action of the dipping fluid. It is therefore desirable to dress the end of the stump of the tail occasionally with a little of the compound mentioned in Schedule VII as by this means any clumps or aggregations of ticks (which it should be specially noted are often resistant to the action of the dip) will with certainty rapidly become destroyed.

One of the great objections which has been brought forward by the opponents of short-interval dipping is the alleged inability produced in working oxen, by which after dipping they are prevented from working for a long period. Such an objection has been greatly overstated, and the difficulty (which to some degree does exist with oxen unaccustomed to dipping) rapidly disappears as such animals become habituated to the process and tolerant of the presence of arsenic in their coats.

The general agreement of opinion amongst those who have regularly adopted the short-interval system of dipping in Natal is that oxen can either be worked in moderation shortly after emerging from the dip or can within a few hours perform their usual work, provided an outspan during the hottest hours of the day is afforded. The weight to be given to this objection therefore will be able to be judged at its proper worth, but the stock-owner really desirous of saving his cattle from the inroads of the disease is urged to base his action upon practical results rather than upon the fears or prejudices of those opposed to the adoption of dipping measures.

The writer has had no opportunity of determining to any satisfactory extent the efforts of the new three-day dip upon the working capacity of oxen, but there seems no reason to doubt that whatever difficulty in this respect may have existed in the past will be much reduced by the use of a fluid in which the percentage of arsenic is reduced by one-half even though its application is more frequent. This opinion is based upon the ease with which cattle and horses (entirely unaccustomed to be dipped) will tolerate immersion every three days without any loss of condition, and also upon the reduced residual or accumulated effect (dealt with above) which is found to attend the use of the weaker dip—an effect in all probability in close relation to the question of temporary inability under consideration.

Recognizing the inconvenience likely to be experienced by sheep farmers in the maintenance of two dips (one for sheep and one for larger stock), necessitating the use at times of two different dipping fluids, an endeavour was made to adopt the Laboratory dip for use as a sheep dip. It was found, however, that the usual arsenical percentage was too high to be safely employed except at somewhat lengthy intervals. The reduction of arsenical strength employed in the three-day dip appeared to overcome this difficulty and permit of its use as frequently as occasion demanded, while the soap and oil constituents of the dip promised to prevent the abstraction of the natural fats of the wool likely to follow the use of an alkaline dip (such as arsenite of soda alone uncombined). Weekly dippings in the three-day dip of a small experimental flock of clean sheep being tolerated for a lengthy period without an inconvenience or disability it was necessary to observe the more important question of the action of the dip on sheep affected with the disease scab.

This disease was therefore harboured and promoted among a large number (some 160 merino sheep) and was allowed to spread until this experimental flock was very badly affected.

Schedule XV will give the more precise details of the experiment, but it may be said here that by a repetition of the process of dipping (which did not in the least affect the health or condition of the flock) the disease was rapidly eradicated, since which time the entire flock has passed through the dipping tank, being completely immersed each time, without the loss of a single sheep, the number of such weekly dippings totalling eighteen up to the present.

It would appear therefore that the three-day dipping fluid will be found to be adapted well to the requirements of the sheep-owner who—if possessed of a full-sized dipping tank—can with a minimum of trouble arrest the first signs of an outbreak of scab in his flock by passing his sheep or goats through the same dip as that which he is using in the endeavour to fight the disease East Coast fever or clear his farm from ticks.

If stock-owners once recognize the fact that by the adoption of any system of dipping they will be able:—

(1) To check with certainty, and with little or no loss, an invasion of East Coast fever;
(2) to arrest with certainty and ease any manifestation of the disease scab in their flocks; and
(3) to look forward with confidence in the near future to the practical eradication of the disease-producing tick from their farms;

the greatest problem affecting the agricultural welfare of South Africa will be well advanced towards its solution.

Such a system has been attempted to be outlined in the three parts of this "Report on Dipping and Tick Destruction", of which the above is the concluding part.

The question of *time* or the adapting of the dipping process to the life history of the tick has been considered as the essential point of these observations. Such adaptation has necessitated the revision of the composition of the generally used dipping fluids in order to permit a much more frequent repetition of the process than that usually practised, a repetition which, while harmless to the beast, must be lethal to the tick in all its active phases.

For ordinary use as a precautionary and tick-destroying method, in the absence of specific disease, the use of the formula (given in Part I of this report under the name of the Laboratory Dip) will be found to answer the purpose for which it was arranged, viz., that of a regular five-day or weekly dip or spray, and the writer—encouraged by the results which have attended the use of this dip—recommends its continued use in circumstances where no urgency exists.

Good results will be found to attend the use of such of the proprietary dipping fluids now on the market as have been altered to meet the short-interval requirement which our increasing knowledge of the tick and its habits has rendered imperative.

Where, however, the disease East Coast fever is threatening a district or farm which is well fenced, and in all localities where the eradication of the tick pest is a matter of serious moment, the writer strongly urges—even at the expense of increased routine trouble—the adoption of the still shorter interval of three days, confident that the outcome will be greatly to the advantage both of the individual and of the community.

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It is again my duty to express an indebtedness to my Veterinary Assistant, Mr. A. W. Shilston, M.R.C.V.S., both for his valued assistance in the foregoing work and for the many suggestions with which he has advanced the inquiry.

Schedule I.

Shortest Periods for Engorgement of the Larva and Nymph of the Brown Tick.

Preliminary observations were made upon the rabbit by reason of the ease with which this tick was observed to attach itself.

Four rabbits were infested with a number (some thousands) of larvae each. These ticks were placed on their host at 11.45 a.m. on

15th January, and it was found that engorged forms first commenced to loosen their attachment at 11.45 a.m. on 18th January, a period of seventy-two hours precisely.

Control observations were made on cattle, a large number of larval ticks being placed upon the ears of beasts, over which bags were then tied. Several engorged forms were found in the bags as early as sixty-eight hours (10.15 a.m. 15th March to 6 a.m. 18th March), a result which there is no reason to doubt frequently occurs in the case of infected cattle under natural conditions.

In the case of nymphs, observations similar to above were made upon rabbits, the shortest period of engorgement noticed being seventy-one and a half hours.

In the case of cattle, no engorged nymphs could be recovered until the eighty-fourth, while, in repeat experiments, the time was still further lengthened, the period apparently being dependent upon the mean temperature, as, in one case observed during the cool days of early April, no engorgement took place for over five days, although attachment was effected at once. The main deduction from the above observations is that where dipping is relied upon as a check to East Coast fever, such dipping must be made at intervals of not longer than seventy-two hours if the escape of *all* forms of infectious ticks is to be prevented.

Schedule II.

Showing Details of Adjustment of "Three-day" Dip.

The above schedule shows the manner in which the various component parts of the dip were arranged, and also the manner in which the solutions of varying strengths were tolerated by the cattle immersed in them. It will be noticed that three estimations of arsenical strength were experimented with, namely, three-quarters, one-half, and five-twelfths—the strength of the "Laboratory Dip". Further dilutions were also tried, namely, one-third and one-quarter of the strength of this original dip, but it was found that these latter dilutions were not efficient in practice.

The main observations, therefore, were confined to the above strengths which correspond to 6⅜ lb. 4¼ lb., and 3½ lb. respectively of standard arsenite of soda to 400 gallons of water, etc.

A further variation was introduced by omitting, in certain cases, the paraffin and soap mixture in order to test the suitability of arsenite of soda alone when used in such weak solutions.

Further, it will be noticed from the above table that certain dippings were practised at intervals of forty-eight hours (one clear day), while in others the interval was seventy-two hours (two clear days).

Reference to the table will show that the 6⅜ lb. (which is called the three-quarter strength, as compared with Laboratory Dip) when applied every two clear days, resulted in the casting, after the sixth immersion, of the five animals shown, and that they had to be allowed a fortnight's interval before dipping could be recommenced; further experiment with this strength, and at this interval, was therefore discontinued.

In the case of 4¼ lb. to 400 gallons (so-called one-half strength), it will be seen that estimations were made at intervals both of one

clear day and two clear days, and also that separate experiments were made at this arsenical strength by omitting soap and paraffin from the dipping fluid. In these latter cases (minus soap and paraffin), it will be seen that the half strength (4¼ to 400 gallons) necessitated the casting of the experimental animals for some period after nine or ten immersions, owing to cracking of skin, which condition was more pronounced in the animals dipped at only one-day interval. Where, however, the full formula was used, it will be noticed that it was only necessary to omit two of the routine dippings at the one-day interval, and only one dipping at the two-day interval, while the omission in this latter case was not imperative.

After a number of dippings, varying, in the case of the one-day interval, from 17 to 19, and in the case of the two-day interval dip from 11 to 12 immersions, the whole herd was passed with regularity through a dip containing 4 lb. of arsenite of soda to 400 gallons, together with an adjusted proportion of soap and paraffin (see Schedule VII), and it is this composition which is referred to in the foregoing pages as the "Three-day" Dip. Reference to frontispiece will show that between sixty and seventy dippings at this interval have been tolerated without any loss of condition.