DIPPING AND TICK-DESTROYING AGENTS

PART II

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PART II.

In a previous report on the above subject, published last year, I sought to show the efficacy of the various dips or tick-destroying preparations then in general use. The chief object of the inquiry was to ascertain whether such dips were capable of application at short intervals in such a manner that, while all ticks were effectively destroyed, the beast itself would not suffer in the cleansing process. The need of a dip capable of application every few days was shown to be urgent, inasmuch as the usual dipping interval of ten days or longer permitted the possibility between such dippings of the access and escape of one of the forms of tick-life responsible for the spread and perpetuation of the disease East Coast fever. The endeavour, therefore, was to ensure that any tick gaining access to a beast—however brief its stay on its host might be—could not escape the certainty of becoming poisoned by the dipping to which its host would every few days be subjected.

Examination of most of the dipping fluids, however, revealed the fact that the manufacturers of the same had so adjusted the arsenical strength of their preparations as to make them capable only of application at intervals of some ten days or a fortnight, and dippings at shorter intervals than these were found impossible by reason of the dangerous effects produced upon the beast. A few dips were, indeed, capable of application at short intervals, but such were at the same time found to be deficient in tick-destroying properties and consequently of little or no use for the intended purpose. An effort, therefore, was made to arrange a dipping fluid which, while permitting application every few days, would at the same time prove efficient as a destroyer of tick-life. The outcome of the inquiry was, as set forth in Part I of this report, the arrangement of a dipping fluid—"The Laboratory Dip"—which has since been used very extensively throughout the Province of Natal and has given excellent results as a short-interval dip.

The following observations, therefore, which constitute Part II of the report, deal less with the composition and practical use of a successful dip than with the manner in which the effects of such a dip are exerted both upon the animal economy and upon the tick itself.

A system of treatment which entailed the total immersion of cattle at intervals of a few days in a poisonous fluid, such as a solution of arsenic, was recognized from the first as a system which would need the most careful watching in its application. The effect of the regular submersion of cattle, even in water, at short intervals seemed a sufficiently marked departure from the natural habits of the domesticated ox to necessitate close observation in its effects upon the health of the animal, but where a highly poisonous fluid (such as an arsenical solution) was employed the need for extended and careful observation was naturally greatly increased before the adoption of such a system could be recommended. Wide practical results, however, have fully justified the hopes which were entertained regarding the usefulness of such a system of short-interval dipping, and the succeeding observations are designed to prove that the advantages of the adoption of such a system are not merely the advantages to be expected from a more frequent immersion of the beast and the more frequent "mechanical"—if I may use the term—killing of the ticks upon its body by such immersion. Such increased killing effect would in itself justify the system in districts where, as in East Coast fever, the rapid destruction and restraint of tick-life was of paramount importance. This advantage, however, is of even less importance than the striking secondary results which are found to attend the adoption of short-interval dipping, which results, so far as the question of tick destruction is concerned, would appear in the aggregate even to exceed the destructive effect of actual immersion upon those ticks which are carried by the beast through the dipping tank itself.

These secondary results, which follow only frequent dipping or spraying at short interval, 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. This cumulative effect is, as will be seen, a far reaching one, for an ox in such a condition will be the means of collecting and destroying a large number of ticks apart from those which he actually takes into the dip and destroys by immersion in the dipping fluid.

The excretion or throwing off from the system of the accumulated arsenic is, however, a rapid process, as will be seen from schedules given below, 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. A comparatively long interval of, say, ten days or a fortnight between dippings appears from the evidence collected to be too long to permit of the establishment and maintenance of this condition of maximum accumulation, and an animal dipped at such intervals would appear to be able only to act as the vehicle by which ticks are collected and conveyed to the dipping tank, there to be killed by submersion in an arsenical fluid.

That a beast can be safely habituated to the system of short-interval dipping with an arsenical fluid of known composition and strength is abundantly proved by the Natal results of the past two years, many thousands of animals having been regularly subjected to the process in this Province every five days without danger to their use for food purposes or detriment of their health and condition, and with the best results as regards the suppression of tick-life in general. Some stock-owners have reported the fact that the growth of the animal's hair seems to be stimulated to a considerable degree by frequent dippings (a cause for which effect is suggested in Schedule E), but no reports of any attendant evil effects—apart from avoidable accidents—have been received, the weight of evidence being consistently favourable and encouraging to the wider application of this system of dipping. It may be taken then as satisfactory proof that an animal can be accustomed to frequent immersion or dippings in an arsenical fluid without damage to health or check to growth. Habituation to arsenic, taken internally, has long been recognized as a possibility. In lower Austria it will be remembered that arsenic is eaten with impunity by the mountaineers and their families, being used as a condiment or combined with sugar as a sweetmeat. The giving of arsenic to cattle and horses to improve their appearance has long been practised, while in certain parts of India native horsemen carry lumps of white arsenic from which their horses are induced to bite or nibble small pieces during a journey in order to improve their powers of endurance and speed. In all such cases, however, gradual habituation is necessary, otherwise poisonous effects are produced. This same necessity for gradual habituation holds to some extent in the use of the short-interval system of dipping. It has been a matter of frequent observation that herds not accustomed to any dipping will become scalded and otherwise affected by their first immersion, and similarly that cattle accustomed to be dipped only once a fortnight will be temporarily affected by a too abrupt adoption of the short-interval dipping of five days. (This point of the establishment of tolerance was noticed in Part I of this report, page 9.) Habituation, however, in any case 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 to 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 point of saturation appears to be a remarkably constant one (as reference to Schedule E, items 1 to 4, will show), and, as far as analysis of the animal's skin shows, no efforts to increase the amount of arsenic by constantly repeated applications of the dip produce any further augmentation of the arsenical content. In fact, as will be seen from the succeeding observations, the deeper layers of the skin appear to be capable of becoming so tolerant of the presence of arsenic that the latter becomes tolerated to a considerable extent That this accumulation is not a mere mechanical deposition or passive soaking, but is rather a vital and active process, is indicated in Schedule E, items 5 and 5*a*. Here it will be noticed that the endeavour to increase the arsenical content in the fresh skin of a dead beast is not attended by success. In fact it will be seen from the schedule that the actual amount of arsenic in the skin is less (perhaps through its contraction after death), although extra post-mortem spraying has increased the arsenic content of the hair covering the skin. This indication of the vital action of the skin 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 bloodvessels which are contained in its deeper layers, such excess of arsenic appearing shortly afterwards in the urine (Schedule F). When we further consider it is into this deep layer of the skin that the tick thrusts its mouth parts and obtains its nourishment, we shall partly see the significance of being able to establish and maintain a supply of arsenic at such a point of attack. This ability of the skin to absorb and tolerate the presence of considerable quantities of arsenic is a point of interest also, in view of the generally accepted theory that the normal skin of an animal is not capable of absorbing arsenical solutions. It would appear, however, as said above, that not only is such active absorption possible, but, further, that the living skin is capable of so adapting itself as to tolerate, and even store, considerable traces af arsenic without departure from its normal functions or condition.

Such a fact would appear to be of useful application in the South African problem of the eradication of the tick, with all its attendant evils.

Inspection of Schedule E shows that the hair and epidermis, or scurf, of a beast's skin retains also a remarkable quantity of arsenic after dipping or spraying, far more, indeed, than the living skin beneath. One of the interesting points shown below is the behaviour of an animal's hair towards arsenical solutions and the length of time during which arsenic will persist in an animal's coat after dipping. In the Royal Commission on Arsenical Poisoning, which reported in 1908, it is stated that arsenic could be detected in the hair of persons "several weeks after the drug had ceased to be taken", and, further, that it appeared probable that arsenic had a special affinity for epidermic tissues. Such a finding receives strong corroboration from the present work. One instance showing the marked persistence of arsenic in the hair is shown in the case of beasts Nos. 8 and 9 in Schedule E. In this case a small dairy herd was, through carelessness, sprayed on 31st December, 1909, with a solution of arsenic much in excess of the proper strength. Several of the animals died in consequence, and the remainder exhibited symptoms of severe arsenical poisoning. This result so disconcerted the owner that all attempts at future spraying or dipping were abandoned. At the end of June, 1910, several of the surviving animals were purchased for experimental purposes, and it was found that their coats still contained considerable traces of arsenic. In another instance, as showing the persistence of arsenic in the hair, it was found that exposure to an extremely heavy rain (three inches) did not result in the appreciable lessening of the arsenic contained in the coat of the beast so exposed.

While such points are of interest as showing the persistence of arsenic in the external covering or hair of dipped beasts, no very practical deductions can be made from the same, inasmuch as it is by the skin layers below the hair that the poisonous effects are communicated to the tick, and it is probable that the mere presence of arsenic in the hair itself has but small effect upon the tick. An animal dipped every fortnight might thus hold the same amount of arsenic in his coat as one submitted to short-interval dipping,* but the same quantities existing in the skin itself would differ widely, while the actual tick-killing potentialities of the two animals could hardly be compared. It is now possible to understand the reason for the frequent instances which have been brought to notice in which owners of herds have expressed their disappointment at the

* Compare the arsenic in coats of No. 5 after eight weeks, and in beast No. 2 sprayed for ten consecutive days. (Schedule "E".)

non-effectiveness of their first dippings in cleaning their cattle from ticks, but have subsequently reported their entire satisfaction with results obtained. This early ineffectual period we now recognize as corresponding to the stage of incomplete habituation, during which ticks gaining access to a beast after dipping have remained in evidence until actual immersion in the dip ultimately poisons them. In addition to this, it will be seen on reference to Schedule C that the lethal effect of actual immersion on ticks is more pronounced where they happen to be attached to habituated rather than to unhabituated animals at the time of or just before dipping. This result suggests the probability of the tick becoming poisoned both by ingestion of arsenic (by sucking it from the skin) and also by the absorption of the poison deposited upon the external surfaces of its body during the process of dipping or spraying. This latter means, by which the destruction of the tick is brought about, takes effect only in the actual process of dipping, while, in the former case, its action is continuous and sustained, and is probably exerted almost as powerfully before dipping as it is afterwards. We thus see that the value of frequent dipping lies in the sustained effect produced rather than in the mechanical destruction of ticks which follows immersion in the dip tank, and, as will be shown below, this maximum killing efficiency of a beast is only to be maintained by the repetition of the dip or spray process with such frequency as will compensate the skin for the loss of arsenic which is continuously absorbed from it by the blood and excreted in the urine by a natural process of elimination. Examination of Schedule B will show that the power of an habituated animal to destroy ticks placed upon it (or gaining access in the natural manner after dipping) is rapidly lost, five or six days lapse sufficing to reduce such an animal to nearly the same condition as that which exists in the case of the unhabituated animal or beast which is dipped at the long interval of, say, ten days or a fortnight.

The fact that the blood absorbs any excess of arsenic from the skin might lead to the inference that it is the circulating blood which proves poisonous to ticks becoming attached to an animal. That this is not so may readily be shown by taking an unhabituated beast and attaching a number of ticks over a given limited area (as under the tail). If the animal is now thoroughly sprayed all over its body, and care taken to except this small area, and guard against its being moistened by the arsenical solution, it will be found that the attached ticks will remain unaffected, showing thereby that the destruction of the tick is effected by strictly local influences, either by the deposit upon its body directly of the poisonous fluid itself or by the process of imbibition, or sucking, of the same from the deeper layers of the skin of an habituated animal.

Conversely, it can be shown that the poisonous effect, though strictly local, is not due to a simple deposition on the surface of the skin, resulting from one or more dippings. If, in an habituated animal, a patch of skin is shaved closely and then thoroughly washed so as to remove all deposited arsenic with the hair and surface epithelium before attaching the ticks, the lethal result will follow to the same degree as in the case of an habituated animal in which such precautions have not been taken. The practical bearing of such observations, therefore, 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 "heel of Achilles"—the one small vulnerable point of attack—through which infection may become established.

If care is taken to notice the number of animals passing through a dip which manage to escape a complete contact with the dipping fluid, the percentage will be found considerable. Many beasts will fail to completely immerse their heads, the root of the ears and poll frequently escaping, while others will be found to keep the tail so close that a dry area will be formed under its root after the beast emerges from the dip, or the ears will be held closely applied to the head, thereby avoiding the thorough irrigation of their interior surfaces. Completely effectual immersions will not, as a rule, be found in much more than 80 per cent. of cattle dipped, especially where beasts are hastily hustled through a dip-tank. These points 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. Where such measures as the above are adopted upon a fenced farm the eradication, or reduction to a minimum, of tick-life is accomplished within a surprisingly short space of time, but where, in stead of the system of short-interval dipping, an interval of two weeks has been allowed to elapse, the progress towards eradication has been much slower, such an interval, especially during hot weather, permitting the increase of innumerable ticks which, under the system of short-interval dipping, would either have been poisoned upon the beast or have met their destruction through the more frequent immersion necessitated by that system.

The following schedules may, perhaps, be open to the objection that they have been based upon meagre data. This may be so, but it is thought such data will be found ample enough to establish the point at issue in a sufficiently conclusive manner. Although the foregoing observations have been based upon the action and effect of an arsenical fluid of known composition*—the "Laboratory Dip"—it is probable that several of the proprietary dips, recently adjusted and now before the public, would have given equally satisfactory results.

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* The maintenance of such dipping fluids at their proper strength is a point of some importance, neglect of which has been the cause of both failure and loss in several known cases. This difficulty of maintaining the proper arsenical strength can be, in a great measure, overcome by the use of a simple appliance devised by my brother, Dr. Watkins Pitchford, by which the farmer can, at any time, ascertain the exact strength of his dip, even though he has no specialized knowledge.

The endeavour of the writer, however, has been simply to show that arsenic (in certain definite proportions and combinations) is capable of more effective use as a destroyer of tick-life than has been generally accepted in the past. Its further influence in retarding the development of pathogenic germs after their inoculation is a point also likely to prove of utility in the suppression of tick-borne diseases. Apart, however, from the control of tick diseases, the economic loss to South Africa from tick ravage is considerable, and it is hoped that the widening of our knowledge, however slightly, will tend to advance the time when the eradication of the tick from South Africa will be considered as a not impracticable policy.

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SCHEDULE "A".

THE ABILITY OF AN ANIMAL TO KILL TICKS PLACED UPON IT INCREASES WITH THE NUMBER OF DIPPINGS SUCH ANIMAL RECEIVES.

1. *One Spraying (or Dipping)*—
   No. of animals: 2.
   No. of ticks applied to each: 6.
   No. 1. All ticks alive and attached after twenty-four hours; two dead next day, and one the day following.
   No. 2. Five ticks alive and remaining attached after three days (engorged).
2. *Two Sprayings*—
   No. of animals: 2.
   No. of ticks applied to each: 6.
   Interval between sprayings: 24 hours.
   No. 9. One tick dead in twenty-four hours, the remainder being removed in course of experiment (see below).
   No. 10. Three ticks dead in 24 hours, the remainder being removed.
3. *Three Sprayings*—
   No. of animals: 6.
   No of ticks applied: 1 infected tick to each.
   Interval between sprayings: 3 days.
   No. 19. Removed alive after 15 minutes.
   No. 20. Removed alive after 2 hours.
   No. 21. Dropped after feeding for 2 hours.
   No. 22. Dropped after feeding for 3½ hours.
   No. 23. Dropped after feeding for 1½ hours.
   No. 24. Moribund after 3 hours; removed dead in 24 hours.
4. *Four Sprayings*—
   No. of animals: 6.
   No. of ticks applied: 1 infected tick to each.
   Interval between sprayings: 3 days.
   No. 13. Tick removed alive after one hour.
   No. 14. Tick dead within 24 hours.
   No. 15. Tick dead within 24 hours.

No. 16. Tick removed alive after 30 minutes.
No. 17. Tick removed dead after 6 hours.
No. 18. Tick removed dead after 6½ hours.

N.B.—In the case of two, three, and four sprayings, the ticks were only induced to attach themselves with difficulty.

Observations upon Schedule "A":—

It will be noticed that the ticks, in the case of one spraying, survive, the animals Nos. 1 and 2 being unable to exert any poisonous effects upon the ticks subsequently placed on them.

In the case of two sprayings, animals Nos. 9 and 10 permit the survival for a period of twenty hours of the majority of their ticks.

In the case of three and four sprayings, only one tick (infected) was attached to each animal, the endeavour being to ensure the infection of the animals in question by the smallest number of ticks.

The results upon the individual ticks would appear to indicate in a satisfactory manner the increasing killing capacity of the skin of the beast. In the case of four sprayings, the lethal effect upon the tick is well marked, a few hours in some cases sufficing to ensure its destruction.

In the above cases the skin at the point of the attachment of the ticks was thoroughly cleansed to ensure the absence of arsenic which might have become deposited upon the surface from the spray.

N.B.—Throughout the succeeding observations the process of spraying or dipping has been adopted indifferently, the strength of the spraying and dipping fluids being equal in all cases.

SCHEDULE "B".

THE LENGTH OF TIME ELAPSING SINCE THE LAST DIPPING DETERMINES THE ABILITY OF AN HABITUATED ANIMAL TO KILL TICKS WHICH MAY BECOME ATTACHED TO IT.

	Days since Dipping.													
	1 day.		2 days.		3 days.		5 days.		7 days.		10 days.		Non-dipped Controls.	
No. of Beast.	No. 8	No. 20	No. 1	No. 21	No. 11	No. 19	No. 22	No. 25	No. 16	No. 24	No. 26	No. 23	No. 6	No. 9
No. of Hours since attachment of Ticks.	No. of Ticks attached.		No. of Ticks attached.		No. of Ticks attached.		No. of Ticks attached.		No. of Ticks attached.		No. of Ticks attached.		No. of Ticks attached.	
	6	6	10	9	10	12	17	11	10	11	13	13	4	4
12	4	6	10	8	9	12	12	10	10	10	11	10	4	4
24	1	2	4	5	5	3	5	10	8	6	9	6	4	4
36	0	0	1	4	5	3	4	9	6	6	8	6	4	4
48	0	0	0	2	1	2	3	9	6	6	8	6	4	4
72	0	0	0	1	0	0	0	8	3	6	7	6	4	4

Observations on above:—

The main indications of this experiment are sufficiently clear to show that—even after an extended period—the influence of habituation is exerted to some degree. During the three or four days succeeding dipping the lethal capacity of an animal appears considerable, but this power drops in a week or ten days so that only about 50 per cent. of ticks attaching themselves would be poisoned. The lessened ability of certain animals to deal with ticks gaining access to their skin (c.f. No. 25 above), is noticed in observations on Schedule F. In none of the unhabituated animals—of which several were used as controls—were ticks observed to be other than vigorous, no dead ones being at any time found.

SCHEDULE "C".

Observations to show that in Habituated Animals the effect on Ticks of a given Dipping is more rapid than in Non-habituated Animals.

	Habituated.			Non-habituated.			
No. of Beast.	No. 11	No. 19	No. 39	No. 6	No. 29	No. 31	No. 33
Hours after Dipping.	No. of Ticks attached before Dipping.			No. of Ticks attached before Dipping.			
	15	7	14	16	10	7	13
	No. of Ticks surviving after Dipping.			No. of Ticks surviving after Dipping.			
3	4	5	10	16	7	7	12
6	4	1 Moribund	3	13	7	7	10
9	3	0	1	5	4	4	8
20	0	0	0	2	0	1	3
24	0	0	0	1	0	0	2

Observations on above:—

It will be seen from the above table that the rapidity with which an habituated animal is able to deal with the majority of its ticks during the first few hours after dipping, is greater than in the case of non-habituated animals; thus at 6 hours the habituated animals show the survival of only 27, 14, and 21 per cent. of their ticks, while the unhabituated retain alive 70, 77, 81, and 100 per cent. of their ticks respectively.

SCHEDULE "D".

Observations to show the Retardation of the Infective Process in the Habituated Animal.

Days since Exposure.	A Control animals, not dipped, and exposed to infected veld for periods as shown.					B Animals dipped, only after exposure to infected veld, for periods as shown.					C Animals dipped 24 hours before and also after exposure to infected veld for periods shown.				
	½ hr.	2 hrs.		6 hrs.	9 hrs.	½ hr.	2 hrs.		6 hrs.	9 hrs.	½ hr.	2 hrs.		6 hrs.	9 hrs.
	28	30	33	6	27	29	31	32	9	26	11	19	20	18	12
1	100·6	102·6	99	101·4	102·2	100·4	101	100·5	102	101	100·2	101·2	99·4	101·6	100·6
2	100·8	102	101	101·8	99·8	102·6	101·2	101	101·2	100.6	100·6	100·4	101·2	101·8	100·6
3	101	101	102	102	99·6	102·6	100·6	100·4	101·6	101	100	101	101·6	102	100
4	101·2	101·2	101·7	102	101·4	101·6	103	101·7	101·8	101·6	100·4	99	102	102·6	100·4
5	101·4	100·6	102·4	101·8	100	102	101·6	101·4	101·4	101·2	101·4	100·4	101·4	102	100·6
6	100·6	101	102	101·4	101·4	101·6	102	101·2	101·4	101·8	100·6	99·6	102	102	101·2
7	101·4	103	102·7	101.4	99·7	99·6	100	101·3	101.6	101·4	100·8	97·6	102·6	101·6	99·8
8	101·8	104·8	103	101·8	102·6	100·8	102	102	101·6	101·4	101	102	102	102·6	100·6
9	102	106·2	102·2	101·4	104·6	101·4	101	101	102	101·6	100·4	99·6	102·4	102·6	102
10	105	105·6	102·6	101	104·6	101·8	102	101	101	102·6	101·2	100·2	101·7	100·6	101·6
11	105·2	105·6	103·6	104	105·4	101·7	103·6	102·8	101·4	104	100·8	101·2	102·2	101·6	100·4
12	105·4	105·4	103	105·2	105·6	103	106	102	101	105·8	100	100·6	102	102	100·4
13	105·8	106·2	104	105·6	105·7	104	106·8	101·8	101	105·6	100	100	102	102	101·6
14	106·2	106·4	104	106	105·4	104·6	105·4	101·7	101·6	105	100	100·4	100·4	102·2	100·4
15	105·8	106·2	103	106·2	105·7	104	106·8	102	101·6	105	99·6	103·2	100·4	101	100·4
16	106	106·4	104	105·8	105·4	104·6	105·4	101·6	102	105·6	100·6	105·4	101·2	101·4	101·6
17	105·6	107·2	103·7	106·6	105·4	103·8	106	102·6	101·6	106	100	106·3	101·6	101·8	100·8
18	105·6	105·7	105·6	105·2	105	103·8	104·8	103·6	101·6	106·4	99·8	105·6	103·6	101	103
	10th day.	7th day.	8th day.	11th day.	9th day.	12th day.	11th day.	12th day.	—	11th day.	—	15th day.	18th day.	—	15th day.
	Average period of incubation: 9 days.					Average period of incubation: 12¾ days.					Average period of incubation: 16 days.				

Observations upon Schedule "D":—

The above table shows the distinct influence of dipping in lengthening the period of incubation of East Coast fever.

Where dipping followed directly after the exposure to infection (Table B), the average period of onset is over the twelfth day, while one out of the five animals exposed to the infection has failed to react up to the twenty-fourth day.

Where dipping precedes by twenty-four hours and immediately succeeds such exposure to infection (Table C), the average incubation period is extended to sixteen days, while here two beasts have failed to contract the disease.

In Table A all the animals have become infected during the period of their exposure at an average incubation period of nine days. The temperatures shown are in all cases morning temperatures, the midday and evening registrations being more pronounced.

The numbers of animals comprising this experiment are small, but the final comparative results show satisfactorily the undoubted influence exerted by the arsenical applications.

Notes taken as the animals were removed from the infection paddock showed that infection by nymphal brown ticks existed in every case, though never to an excessive degree. Adult brown ticks were only occasionally noted. The effect of dipping or spraying upon these immature ticks is so rapidly exerted that, an hour or two after the application of the fluid, the majority will be found dead, and it is probable the poisoning process begins directly the arsenical solution is brought into contact with the insect. In adult ticks—which are more hardy—the legs commence to straighten out and relax their hold in from two to three hours after dipping, this being especially the case where they are attached to an habituated beast. Such observations go to prove that the actual infection of an animal is rapidly established after the attachment of the infective tick, and the persistence of the tick for any length of time at the point of its attachment is not necessary for the accomplishment of the infective process.

The lengthened period of incubation shown in the above table shows that the restraining influence is one exerted upon the disease germ itself after its deposition by the tick in the deeper layers of the animal's skin rather than to a restraint exerted upon the actual mechanism of infection by the tick.

The importance therefore is obvious of so habituating a beast that the deeper layers of his skin may become able both to poison the tick and also to exert a restraining influence upon the development of the disease-germ itself, though whether this restraint can be exerted to such an extent as will permanently hold back the development of such germ—is a matter for further observation.

The extension of the incubation time, however, from an average of from nine to at least sixteen days proves that a degree of restraint hitherto unsuspected is possible to the habituated animal apart from his increased power as a tick destroyer.

SCHEDULE "E".

Estimation of the amount of Arsenic retained by the Hair and Hide of Animals for varying periods after Dipping.

Number 1.

Devon heifer.

Skin: Very thin, 1 sq. ft., weighing 6½ oz.

Hair: Long, fine, and thick.

Sprayings: Last six sprayings in twenty-four hours; previously every fifth day.

Killed: Twenty-four hours after last spraying.

Analysis: 1 sq. ft. of skin contained:—

In Hair and Scurf.	In Skin itself.
.302 gramme, or 4.6 grains.	.228 gramme, or 3.518 grains.

Number 2.

Black and white bull.

Skin: Medium thickness.

Hair: Strong, medium length, but not thick.

Sprayings: Daily for ten days; previously every fifth day.

Killed: Twenty-four hours after last spraying.

Analysis: 1 sq. ft. of skin contained:—

In Hair and Scurf.	In Skin itself.
.201 gramme, or 3.1 grains.	.196 gramme, or 3.02 grains.

Number 3.

Devon bull.

Skin: Medium thickness.

Hair: Fine, long, and very thick.

Sprayings: Every five days for months, and last sprayings every third day.

Killed: 24 hours after last spraying.

Analysis: 1 square foot of skin contained:—

In Hair and Scurf.	In Skin itself.
.527 gramme, or 8.1 grains.	.224 gramme, or 3.45 grains.

Number 4.

Black heifer (Kaffir).

Skin: Very thick, 1 square foot weighing 18 oz.

Hair: Strong, medium length, fairly thick.

Sprayings: Every five days for several months.

Killed: Five days after last spraying.

Analysis: 1 square foot of skin contained:—

In Hair and Scurf.	In Skin itself.
.352 gramme, or 5.4 grains.	.251 gramme, or 3.87 grains.

Number 5.

Short-horn heifer.

Skin: Not taken.

Hair: Fairly long, fine, medium thickness, 26.55 grammes to square foot.

Sprayings: Once five days before death. Not previously for eight weeks.

Analysis: 1 square foot of hair contained:—

116 gramme, or 1.8 grains.

The carcass of this beast was sprayed immediately after death, and after drying 1 square foot of skin was removed weighing $8\frac{3}{4}$ ozs.

In Hair and Scurf.	In Skin itself.
.47 gramme, or 7.25 grains.	.008 gramme, or 0.123 grains.

Number 6.

Cross-bred steer.
Skin: Fairly thick.
Hair: Moderately long.
Sprayings: Dipped regularly for several months, killed ten days after last dipping.
Analysis: 1 square foot of skin contained:—

In Hair and Scurf.	In Skin itself.
.26 gramme, or 4 grains.	.137 gramme, or 2.1 grains.

Number 7.

Short-horn steer.
Skin: Not taken.
Hair: Fairly long, fine, medium thickness, weight being 26.55 gms.
Sprayings: Last spraying eight weeks before removal of hair.
Analysis: Hair and scurf from 1 square foot contained:—
.159 gramme, or 2.45 grains.

Number 8.

Calf: Was sprayed six months before taking hair (see text), 1 square foot of hair contained:—
0.388 gramme, or .6 grain.

Number 9.

Calf: Sprayed seven months before taking hair; 1 square foot contained:—
.0194 gramme or .3 grain.

Observations upon Schedule "E":—

The main points of interest above are the ability of retention of arsenic by the skin itself, and also the extent to which the hair absorbs and retains the same.

In No. 1 above, the endeavour was made to increase the arsenical content of the skin by a repetition of the spraying process every few hours, allowing time only for the previous spraying to dry, the animal having been previously dipped every five days for many months. The approximate amount of arsenic in one square foot of hide removed after death was $3\frac{1}{2}$ grains, or less even than in the case of the animal No. 4, which had been simply dipped every five days but whose skin contained—in a similar area—nearly 4 grains. Daily sprayings for ten days (No. 2) after previous habituation gives even a lower figure (3.02 grains), while after ten days' cessation from his regular five-day spraying, No. 6 still possesses 4 grains of arsenic to the square foot.

Differences of thickness in the skins estimated probably accounted for corresponding differences in arsenical content to some extent, for such differences in weight of one square foot taken from the same region of different beasts varied greatly. Such variance, however, cannot explain the great disparity existing between cases No. 1 and 4, where the much lighter square of skin ($6\frac{1}{2}$ oz.) contained nearly as much arsenic as the piece almost three times its own weight and thickness.

The differences in the rate of elimination as well as the lengths of time since spraying would also determine to no small extent the differences observed in the arsenical contents.

(This question of rate of elimination is dealt with in Schedule "F".)

The main point brought out by the skin figures above is—considering the variations of time, interval, etc.—the constancy of the physiological "saturation point", which varies in the skins of fully habituated animals such as Nos. 1, 2, and 3, only from 3.02 grains to 3.87 grains.

Where an animal such as No. 5 has been allowed to remain free from arsenical applications for an extended period such as eight weeks, the skin content is seen to have fallen to less than half a grain, while ten days since the last dipping allows the arsenical content of the skin to fall to two and one-tenth grains (No. 6), at which point the beast was unable, in forty-eight hours, to kill any of the ticks with which he was experimentally infested.

Examination of the figures given for the hair are interesting as showing the persistence of traces of arsenic (in Nos. 8 and 9) after six and seven months respectively, and also as confirming the extent of the "affinity" of epidermic structures alluded to elsewhere.

SCHEDULE "F".

To show the Elimination of Arsenic by the Kidneys at Varying Periods after Dipping.

Number of Beast.	Percentage of Arsenic in Urine at intervals since Spraying, *ut infra.*							
	3 hours.	6 hours.	10 hours.	24 hours.	32 hours.	48 hours.	56 hours.	72 hours.
20	·015	·021	·028	·024	·032	·027	·019	·045
19	·06	·083	·049	·044	·022	·036	·043	·039
31	—	·053	·097	·057	·036	—	·023	·011
12	—	·077	·095	·027	·024	·004	·015	·024

Observations upon Schedule "F":—

The above observations were suggested by (1) the constancy of the point of physiological saturation (as noted in Schedule "E") and speculation as to the probable channel by which arsenic in excess of that amount became eliminated, and (2) from the varying behaviour of certain cattle (in respect of their tick-killing properties) after exposure to equal arsenical treatment.

The presence of arsenic in the urine after dipping proves its active absorption by the living skin, and also tends to disprove the generally accepted theory of the non-absorption of watery solutions by the skin.

In the schedule above it will be noticed that the period of maximum excretion of arsenic is, in the case of Nos. 11 and 12, during the earlier hours succeeding dipping (from the sixth to the tenth hours), and that after this period a rapidly decreasing output is observed. This falling off is not so marked in the case of No. 19, although the figure during the first six hours is very high; No. 20 maintains a steady output, being higher at seventy-two hours (when observations were discontinued) than at any previous time. This beast was chosen for urine examination because he rapidly destroyed any ticks placed upon him. No. 19 possessed the usual tick-killing capacity, while Nos. 31 and 12 were chosen as being unusually deficient in this respect. The results of the examination of the urine of the above animals strongly suggests the existence of a varying individual tick-killing power determined—on the one hand—by the serviceable retention, or—on the other—by the too rapid elimination of the arsenic gaining access to the skin through dipping. Further confirmatory observations on this point would be of interest, though their practical value would not be great inasmuch as the refractory or non-tick-killing condition is only found in a minority of animals so far as I have been able to determine.

Notes on Technique, Etc.

The methods by which the arsenical estimations were arrived at were those in general use. The quantitative figures given in Schedules "E" and "F" have a strict comparative value amongst themselves, and these were obtained by the usual methods of quantitative analysis.

Qualitative confirmation was, however, in nearly all cases resorted to as a check to observations, and controls of normal skin and normal urine were used to correct the methods employed. In most cases of skin analysis presence of arsenic was confirmed by Reinsch's method, the more delicate test of Gutzeit being employed in all other cases. A comparative rather than a quantitative value is, however, claimed for the above observations as being the point of practical value to be aimed at.

In the case of urine estimations no measure of the total quantity excreted during the twenty-four hours was secured.

Skin areas were carefully marked off on the living beast to avoid error through stretching, contraction, etc., after death, when such skin was removed from the carcass. The hair was then clipped close and the area of skin shaved as closely as possible. Weighings were then made of skin and hair.

Ticks used for the purpose of determining the lethal effect of sprayings, dippings, etc., were mainly adult red ticks (*R. evertsi*), though brown (*R. appendiculatus*) nymphal and adult forms were frequently used, and occasionally bont (*A. hebraeum*) and bont-legged ticks (*H. aegyptium*) were secured for the purpose.

The infections produced by exposure to infected paddock were in all cases uncomplicated East Coast fever, a point which was ascertained both by the finding in the corpuscle of the appropriate organism and by the presence of Koch's bodies in the gland-juice of affected animals.