

THE CATTLE TICK

(Boophilus annulatus Say)

Studies of the Effect on the Dairy Cow in Trinidad, British West Indies

by

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C O N T E N T S.

<u>Part I.</u>	<u>Page.</u>
1. GENERAL INTRODUCTION	3
2. REVIEW OF LITERATURE	6
3. OBJECTS OF EXPERIMENT	9
4. SOURCES OF INFESTATION OF TICKS	10
(a) Pasture	10
(b) Close Proximity to Infested Animals	10
(c) Udder Cloths	11
5. LIFE-CYCLE OF TICK - <u>BOOPHILUS ANNULATUS SAY</u>	12
6. LOCI OF ATTACHMENT ON BODY OF INFESTED ANIMALS	15
7. SPRAYING OF EXPERIMENTAL ANIMALS	16
8.A. FACTORS TO BE CONSIDERED IN PLANNING AND CARRYING OUT THE EXPERIMENTS	18
(i) Site of Experiment	18
(ii) Selection of Experimental Animals	20
(iii) Length of Trial Period	23
(iv) Housing and Feeding of Experimental Animals	23
B. DESCRIPTION OF TRIALS	25
(i) Plan of Experiment	25
(ii) Records Taken	26
(iii) Daily Routine	27
C. RESULTS OF EXPERIMENTS	28
(a) Fever caused by Ticks	28
(b) Effect of Ticks on Milk Production	32
D. DISCUSSION OF RESULTS	35
9. EFFECT OF SPRAYING IN AN ARSENICAL SOLUTION UPON THE YIELD OF MILK	37
10. GENERAL	

	<u>Page.</u>
10. GENERAL OBSERVATIONS ON EXPERIMENTAL ANIMALS	39
11. SUMMARY AND CONCLUSIONS	42

Part II.

HAEMATOLOGICAL STUDIES OF EXPERIMENTAL ANIMALS	44
1. INTRODUCTION	44
2. REVIEW OF LITERATURE	45
3. OBJECTS OF EXPERIMENTS	50
4. TECHNIQUE OF BLOOD SAMPLING	50
5. APPARATUS AND METHODS USED IN BLOOD ANALYSIS	51
6. BLOOD PRESERVATION AND ANTICOAGULANTS	53
7. RESULTS OBTAINED	55
8. DISCUSSION OF RESULTS	58
9. SUMMARY AND CONCLUSIONS	60
10. RECOMMENDATIONS	62
11. ACKNOWLEDGEMENTS	63
12. BIBLIOGRAPHY	64
13. APPENDICES I	67
II	69
III	72

1. General Introduction.

The effects of parasites on the feed requirements, growth and development of animals has become a highly important study, especially in areas where the animals are raised in large numbers and where conditions are otherwise favourable for infestation. Parasites are known to produce diverse symptoms and lesions involving not only digestion, but the respiratory, muscular, glandular and other systems as well. In the delicate mechanism of the animal body, parasites are like sand in machinery. They produce irritation by their presence and also by their secretions and excretions. Animals, heavily parasitised, fail to make normal growth even with liberal feeding and their weakened condition invites the onset of other diseases of bacterial origin.

For many years, the presence of the common cattle tick, zoologically known as Boophilus annulatus Say, in Trinidad has been a serious impediment to the development of the dairying industry in the island. Not only are infestations of this tick responsible for heavy losses in dairy animals, but it is also the vector in transmitting tick fever of cattle. On account of the enormous losses occasioned in this connection, this ecto-parasite has presented an obstacle to the introduction of better breeds of non-immune stock from tick-free areas, hence the improvement of native stock, and in particular, dairy animals, has been greatly impeded.

Sub. May 64 Smith and Kilbourne (1) in 1893 showed the protozoan Babesia (Piroplasma) bigemina to be the causative organism of splenic or tick-fever, also variably known as Redwater, Texas cattle fever etc. While inhabiting the blood of diseased animals, this protozoan parasite is intracorpuscular. Due to the ravages of the tick in the Southern United States, the famous eradication campaign of 1906 was begun and

today

today the parasite is well under control.

This species of tick has a wide distribution. Saunders (2) demonstrated its occurrence on cattle in the West Indies where the prevailing climatic conditions are optimum for its development. It also occurs in North, South and Central America, in addition to some parts of Mexico where it is reported as a serious pest (3). In the Southern United States it became well established prior to the tick eradication campaign of 1906 and today only the extreme Southern parts of Texas and Florida are affected to any great extent. In addition to the aforementioned countries, this species of tick is also reported from the East Indies, Asia and Australia (4). According to Stewart et al. (6) 1917, it is considered probable that this tick was introduced into America by cattle imported by the Spaniards during the early colonization of Mexico. These writers also state, from the evidence available, that the importation of Asiatic (Brahma) cattle from Batavia in 1872 was, in all probability, the true cause of the presence of this parasite in Australia.

While the common cattle tick may reach maturity on all equines, and possibly on sheep and goats (3), it is nevertheless almost an exclusive parasite of cattle. All ticks are the mature products of the eggs laid by the adult female ticks. The male tick rarely or never sucks blood while the female requires approximately 18 days on the host to reach maturity. This species of tick is a continuous feeder, that is, all the developmental stages in reaching maturity are effected on the host and once attached, the parasite never leaves the host again until it is mature. A fully engorged and mature female tick, after dropping from the host, completes oviposition in approximately a week. Masses of eggs are laid which require about 21 days to hatch and after a

further

further day or two the resulting seed-ticks crawl to the extremities of grass blades and await a passing host. Once attached, maturity is reached in from 18 to 21 days.

During the feeding period of the tick on the host a certain amount of blood is extracted. Not only does the extraction of blood cause injury, but also the irritation experienced by the host, undoubtedly has its effects on the bodily condition and health of the animal. Cattle with only a slight degree of tick infestation do not appear to suffer any ill effects, but a moderate to heavy infestation will, in all probability, have detrimental effects on the host and with these points in mind, the writer undertook the work of studying the effects of tick infestations on dairy animals at the Government Stock Farm, St. Joseph, with particular reference to the effect on milk production, bodily health and blood composition, including haemoglobin estimations and erythrocyte counts.

2. Review of Literature.

The literature dealing with Veterinary Entomology in general is very extensive and for the purpose of this thesis, the writer has confined his attentions primarily to the literature on that class of the Arthropoda, the Ticks, zoologically classified as:-

Class Arachnida, Order Acarina, Super-family Ixodoidea.

Ticks constitute one of the greatest sources of trouble to livestock in the West Indies (7) and they must definitely be described as a menace to the stock industry, playing an important part in the farming economy of the West Indian islands. Notwithstanding this, however, it is feared that, in some of the West Indian islands, no attempt has been made to deal satisfactorily with the tick problem and the natural sequence of events has shown that the tick, more or less, has had its own way. Normally, the method of "deticking" animals, mostly employed by the peasant possessing a few animals, was to scrape the ticks off by means of a knife or pull them off by hand. This does not by any means afford a good method of control for, though the animal may be completely freed of mature female ticks, it does not account for the numerous seed-ticks which are naturally much too small to be scraped or picked off by hand. Saunders (8) reports that very effective control measures against the tick are used in Antigua. These comprise the use of a spraying machine through which the cattle pass; the spraying solution being Cooper's Cattle Dip - an arsenic-containing preparation. The writer has used a similar type of machine with excellent results at the Government Stock Farm, St. Joseph.

While this Cooper's Cattle Dip - a propriety preparation - is definitely injurious to vegetation, Carroll and Gouck (10) in a recent article on the use of sprays for the control of ticks point out that

nicotine

nicotine sulphate used as a spray against the dog tick (Dermacentor variabilis) was very effective, the ingredients being; 1 part nicotine sulphate (40% nicotine), 1 part of soap and 288 parts water. Figures are also given showing the reduction in abundance of ticks on the ground and on the vegetation after spraying with Sodium fluoride and nicotine sulphate in mixture containing 1.92 ozs. of sodium fluoride, 0.64 ozs. of nicotine sulphate and 0.125 ozs. of neutral soap to 1 gallon of water. In other articles dealing with ticks and their eradication (12, 13 & 14) strong points in favour of dipping, combined with other measures, such as effective fencing, organized rotational grazing of pastures and the alternation of crops involved in the practice of general mixed farming, are put forward. It is pointed out (13) that where cattle are to be completely freed of ticks, the use of the dipping vat is the cheapest and best means of applying the remedy. The writer states that the great advantage of the dipping vat over the spraying machine lies in the fact that thoroughness of treatment is practically assured. On the other hand, however, Saunders (8) states that the use of the spraying machine in Antigua gave excellent results and at least control, if not complete eradication, of the ticks was effected.

Tate (3) working in Puerto Rico states that standard arsenical dips, proved to be effective in destroying the tropical cattle tick, practically all the animals being freed of engorged female ticks after the second or third dipping. In practically all cases after a dipping they were invariably in locations comparatively well protected by long hair. This fact was also observed by Legg (16), working in Australia.

The cattle tick or "creole" tick as it is commonly called, is rife in the West Indies. Saunders (2 & 7) having reported its occurrence from nearly all of the Windward and Leeward Islands. DeJesus (4) reports adequately on the tick problem in the Philippines, while

Tate (3) has given a full account of the life history of the tick in Puerto Rico. The tick problem in Australia has been dealt with by Stewart et al. (6) while a short account of its probable introduction into the Americas and Australia is also given. Much has been written in connection with this species of tick in the United States of America. Woodward & Turner (5) working in Florida carried out an experiment to determine the effect of the tick on milk production in dairy animals. The writers point out the chief detrimental effects suffered by the host and figures relative to milk production and body weights of the experimental animals show clearly that the need for constant control measures is essential. The results obtained by the present writer in a similar experiment at the Government Stock Farm, St. Joseph, bear out the findings of Woodward & Turner in Florida. They found over a period of 140 days, a decrease in the flow of milk up to 18.2 percent between the tick-free and tick-infested groups. Results obtained in Trinidad by the present writer, compare favourably with the above, there being over a period of 70 days, a decrease in the milk yield of 8.3 percent in the wet season and 10.8 percent in the dry season, when the milk yields of the tick-free and tick-infested groups are compared.

3. Objects of the Experiment.

An investigation into the nature of the effects of the Cattle Tick - Boophilus annulatus Say - on the dairy cow was considered worth while since the tick would appear to be one of the major factors limiting milk yield in the tropics. Today dairying is popular and widespread amongst all classes. The truth of this can be demonstrated quickly by enquiry and observation. An industry, such as the dairying one, should be worthy of assistance even if the average size of dairy herds is small and even more so in an island where livestock rearing generally does not figure to any great extent in agricultural enterprises.

In Trinidad, the insufficiency of dairy animals and consequently of milk (17) together with the widespread nature of the dairying industry suggested to the writer that there were problems and difficulties operating against the natural development of a dairy industry conducted along modern lines.

The serious problem of malnutrition among certain classes of the population would be partially remedied by an increased consumption of milk, particularly by children. Therefore, any assistance tending towards an increase in production might also bring about a greater home consumption.

This experiment was primarily designed to find out:-

- (a) the effect of the Cattle Tick on the milk production of dairy animals at the Government Stock Farm, St. Joseph, in both the wet and dry seasons.
- (b) What effect this ecto-parasite had on the condition and bodily health of the animals.
- (c) the nature and magnitude of these effects and
- (d) the effect of spraying in an arsenical solution upon the yield of milk

4. Sources of Infestations of Ticks.

(a) In Trinidad, where the annual precipitation is high and where the annual mean temperature is correspondingly high, environmental conditions, for the development of the cattle tick, are optimal. As has already been pointed out, the cattle tick on reaching maturity on the host drops to the ground where the continuance of the life-cycle proceeds. This, as a rule, takes place while an animal is grazing at pasture. On the other hand, the writer has observed mature female ticks crawling over the concrete floor of the byre. They, in all probability will reach cover, affording a suitable place for egg-laying. However, pastures or rough grazing lands are the main source from which animals acquire infestations. The development on the ground has been well demonstrated by De Jesus (4) working under Philippine conditions. He found that the adult female took 3 days to complete egg-laying in the dry season, and 4 days in the wet season. On the average 20.5 days elapsed before the hatching of the eggs into a pre-parasite larval stage which lasted 4 days. This is the "seed-tick" stage and the stage at which the parasite is infective to animals. Due to some natural instinct, these seed-ticks climb to the extremities of grass blades and await passing hosts. As the host passes, these minute larvae are brushed on to the hairs of the legs and immediately seek out a good place of attachment on the body. Very heavy infestations may be acquired in this way.

(b) In addition to infested pastures an animal may acquire an infestation if kept or housed in close proximity to animals of other species which are also known to harbour the pest. This tick has been recorded from all equines (4) also from goats and sheep (3 & 4) in addition to such wild animals as deer and rabbits. Even under farm conditions where the dairy stock are kept free from the parasite, sporadic infestations may occur due to the fact that the parasite is

maintaining itself and completing its life cycle on horses and mules etc. from which it is frequently recorded. The writer has, in the course of this work, observed the parasite on horses, mules and goats both in Trinidad and in Tobago.

(c) It is the normal practice, prior to the milking of the animal, and in accordance with the accepted principles of dairy sanitation and hygiene in the production of clean milk, to wash the udders with clean water using an ordinary piece of cloth. The writer personally feels that these udder cloths are largely instrumental in the dissemination of ticks amongst dairy stock. The minute "seed-ticks" can easily cling to the cloth and be transferred from one animal to another. The mammary region is a very common site for the attachment of this tick and the writer's observations in this connection were fairly conclusive on the experimental animals under his care.

5. Life History of the Cattle Tick - Boophilus annulatus Say.

For any efficient eradication campaign against any pest, whether it be a crop or animal pest, it is necessary to know the life-history in order to facilitate the work and at the same time be assured of at least reasonable success. This fact is stated by Tate (3) in a paper dealing with the biology of the Cattle Tick under Puerto Rican conditions, prior to carrying out an eradication campaign there.

It is convenient for the purpose of this discussion to start with the mature adult female tick. At this stage the tick has been fertilised and is ready to drop from the host. This usually occurs when the animal is grazing at pasture. Immediately on dropping to the ground, the tick at once crawls about in search of a convenient place for egg laying. A place that affords her shelter from unfavourable conditions and numerous enemies is selected. The chief natural enemies of the tick at this stage are birds and ants. The total period of the life cycle varies depending on the climatic and environmental conditions.

De Jesus (4) in the Philippines found that the life-cycle of this tick was completed in from 48.5 days in the dry season to 50.5 days in the wet season or in an average of 49.5 days. On the other hand, in Puerto Rico (3) it was found that approximately 41 days were required for its completion. There is a preoviposition period ranging from 2 to 6 days but normally approximately 11 days elapses from the time of dropping to the ground until egg laying is completed. The eggs are small, elliptical shaped of a slight amber colour, later changing to a dark brown colour. These tiny eggs adhere in clusters due to a sticky secretion with which they are covered. Over the period of egg laying the body of the tick gradually shrinks and when this process is complete/^{she} dies. In the process of egg laying the part between the thorax and cephalo-thorax splits open and up to 5,000 eggs or more may be laid.

After

After egg laying there is an incubation period of approximately 20.5 days in the Philippines, from 18 to 16 days in Puerto Rico under different climatic conditions and in Trinidad, in an experiment carried out by the writer, a period of 21 days was observed to elapse before the hatching of the eggs in the dry season. The issuing larvae or seed-ticks were small, oval and six-legged of an amber colour later changing to a dark brownish colour. These seed ticks after hatching were observed to remain comparatively inactive for a matter of 3 days, a fact also observed by De Jesus under Philippine conditions. This phenomenon was demonstrated, by placing, in the tube containing the seed ticks, blades of Savanna grass (Axonopus compressus). It was noticed that after the three days elapsed the small larvae became very active and proceeded to climb up the grass blade until they reached to the tip where they again congregated in clusters. This is the stage at which the tick is infective to cattle. Provided a suitable host comes along the tick now begins the parasitic stage of its life. However, if a host is not available to provide the means of completing the life-cycle, these larvae can remain alive for a considerable length of time. In the writer's experiment where the larvae were confined in a glass jar a period of 7 weeks elapsed before the larvae died. Tate in Puerto Rico observed that from the dropping of the engorged female to the death of the last larva a period ranging from 89 to 251 days elapsed.

Once the seed-tick is attached, however, to a favourable host its subsequent development is comparatively rapid. Those places, on the host, ^{that} offer the greatest amount of shelter and protection are sought out by the larvae. Such places include the escutcheon, the flanks, dew-lap, the external genitalia etc. (See. pp. 15 & 16). The seed tick increases in size rapidly, having commenced to suck blood from the moment it became attached to the host.

The larval longevity extends over a period of from 5 to 11 days when the first moult occurs. A new form is produced which has eight legs and is known as a nymph. These nymphs can be discerned on the host but the sex cannot be determined at this stage. This nymphal stage lasts for a period of approximately 7 days, when the second and final moult occurs. The sex can be readily determined after this final moult. The male appears brownish in colour and is oval in shape. The female on the other hand is slightly larger and appears to be very inactive, little movement from her original place of attachment being observed. Mating now proceeds and after fertilisation, the female is mature in approximately 4 days under favourable conditions. De Jesus reports that this stage takes 7.5 days while Tate states that the period from the nymphal moult to the dropping of the engorged female or adult ranged from 5 to 23 days in Puerto Rico.

From the above, it appears that the complete life-cycle of the tick covers a period of from 36 to 40 days. Out of that total period only a matter of 15 to 18 days are spent parasitic on the host. Therefore, in an eradication campaign, it is suggested that the infested animals be sprayed or dipped in arsenic solution once every 14 to 18 days.

6. Loci of attachment on Body of Infested Animals.

During the course of the experiment it was observed that some cows became more heavily infested than others. Generally, cows having black or mottled black and white/coat colour appeared to be more susceptible to tick infestation than cows where the coat colour was entirely white or where the animal showed a greater proportion of white hair to black hair.

Ticks do not appear to tolerate exposure to direct sunlight, therefore it seemed that they instinctively attached themselves to particular places on the body surface where concealment from the direct heat of the sun was offered. In grade Holsteins, such as were used in this experiment, factors affecting or limiting tick infestation appear to be at a minimum. The body surface of this type of animal is covered with fairly long hair which offers excellent shelter from the elements; the skin is reasonably thin in comparison to that of the Zebu (Bos indicus), offering an apparently easily penetrable surface for the insertion of the chelicerae and hypostome of the feeding ticks. From observations, it appears that the health and bodily condition of the animal are major factors in resisting or acquiring an infestation and subsequent maturity of ticks was observed to be quickest on animals showing a dejected appearance. More fleshy and healthier looking animals appeared to be more able to resist the effects of the parasite. Observations on the experimental animals revealed that the degree of infestation was greatest on those parts that offered the maximum amount of protection both against the direct heat of the sun and the arsenical spraying solution. Legg (16) and Tate (3) state that where ticks were found maturing on animals after a dipping, they were invariably in locations comparatively well protected by long hair. These included the escutcheons, the bellies, the sides of the mammary glands, the folds in the skin of the neck, the ears, the dewlap, around the root of the tail

Fig. I



The Spraying Machine showing
"entrance" and "exit" races



Interior completely filled
with fan-shaped spray



The sprayed animal

in addition to the skin around the anus and external genitalia. (3, 4 & 5). Ticks were also observed on the flanks of the animals where the hair was of such a length that practically complete concealment of the tick was effected.

7. Spraying of Experimental Animals.

At the start of the experiment, all the experimental animals were freed of ticks. Thereafter, the animals in the tick-free group were sprayed at approximately 14-day intervals, hence one group was allowed to acquire a natural infestation while the other group was kept free from the parasite during the experimental period. The machine used was Cooper's Cattle Sprayer (Fig. 1) and the spraying solution employed was Cooper's Cattle Dip - an arsenic containing preparation used at a strength of 1 gallon of dip to 150 gallons of water.

This machine has a leading in "entrance race" 7 feet long and a leading out "exit race" 17' 6" long. It is of galvanised iron 10 feet long and 3' 6" at its greatest width and is 6 feet high. The foot boards are 1' 2" wide and the machine is so constructed that the animal is prevented from turning round while being sprayed. The dip is administered by means of atomizing nozzles, in the form of a spray, from pipes which run round the inside of the machine. These nozzles, which send out the dip in the form of a fan-shaped spray, are set from the pipes at various angles properly placed so as to fill the interior of the machine with a fine cloud of spray, which so efficiently soaks the animal when passing through in a matter of a few seconds.

Under the foot boards there are strainers of fine-meshed brass wire gauze, through which the surplus dip passes on its way back to the tank, to be used again. Occasionally stoppages and difficulties are encountered due mainly to dirt and debris, especially from the feet of the animals, finding a way past the brass wire gauzes into the tank,

when

when it appears to have some effect in blocking the nozzles. This, however, does not prove serious and is easily remedied. To obtain this high pressure spray, the dip is pumped from a tank situated at the side of the machine, by means of a pump which requires the efforts of two men for its efficient operation. The dip tank is also made of galvanised iron and is equipped with a gauze so that the amount of dip contained in the tank can be readily determined at any time.

The machine at the Stock Farm is equipped with two pens. These pens are, for obvious reasons, essential and in theory they should have rock or earth bottoms and should be kept free of vegetation. One pen leads to the entrance race while the other accommodates the sprayed animals for drying purposes. It is more essential that the drying pen have an earth or rock bottom in order to soak up the arsenic solution which drips from the bodies of the animals.

The spraying operation has of course, for obvious reasons, to be done on dry days and owing to inclement weather conditions the work of spraying was unavoidably held over a day or two on some occasions during the course of the experiment. However, each spraying was carried out as near to the 14-day interval as was practicable and as a result the animals, during the wet season were completely free of ticks. At the first spraying some of the animals proved to be somewhat refractory but after a time they became quite accustomed to the operation. The animals were found to be dry again in, at most, 15 minutes after spraying.

Concerning the ticks themselves; it is now a well known fact that the method by which they are killed is by ingesting the poison from the skin of the animals in which the arsenic is present for some time after dipping. Thus, it will be seen that the dip has not only

an immediate effect on the ticks but it also has a prolonged protective effect for some time after its application. The writer observed, in this experiment, after the initial spraying, that in two to three days after the operation, the animals showed a complete absence of ticks. As a result of spraying, the animals appeared much more healthy, their skins being pliable and soft, their coats were not "shaggy" or "starey" and they showed no symptom of being hidebound. These features were comparatively obvious in the non-sprayed or tick-infested group. (See pp. 46 & 47).

8. Factors to be considered in Planning and Carrying out the Experiment.

A. (i) Site of Experiment.

The animals selected for this experiment were taken from the commercial dairy herd at the Government Stock Farm, St. Joseph. The feeding and housing facilities there were adequate and the difficulties of milking, milk recording and management were suitably taken care of, there being a permanent dairy staff to attend to the daily routine of the dairy and the management of the dairy animals. Initially it was intended to carry out the experiment at the College Farm where there was sufficient byre space for a limited number of dairy animals and in addition the College Farm possessed a good weighbridge, which the Government Stock Farm lacked. However, the authorities of the Government Stock Farm were not in favour of having some of their best yielding dairy cows housed, managed and milked away from their own premises. This was understandable since the animals were to be kept under experimentation for a considerable time. In addition, it was evident that a commercial dairy of this type, under contract to supply and deliver bottled milk, could not undertake the inconvenience which an experiment of this nature would involve.

The difficulty of a weighbridge now arose since the Stock Farm did not possess one, and an experiment of this nature demanded a reasonably accurate machine situated in close proximity to the farm buildings. Weighings were done on seven successive days at the beginning of the experiment, the middle of the experiment and at the end of the experiment. Weighing at the same time every day tended to eliminate any errors that might arise from the animal's standpoint. Weights of cattle are subject to considerable variation from day to day (41) and these variations would presumably, have been increased had the animals been weighed at different times each day due to the fact that the digestive and rectal capacities are subject to daily variation. The fact that weighings were done for seven successive days at the same time each day tended to eliminate but not entirely to cancel out such errors.

Lush et al. (41) in a paper published in 1928 reported that the probable error of a one-day weight was 4 to 8 lbs. and that by weighing two additional days 42% of this error was eliminated. Even average weights obtained from 10-day daily weighings does not completely eliminate the existence of an experimental error. The relative error of a 1-day weight and a 3-day weight is as the square root of one and the square root of one-third when the comparison is being made between the weight changes made by the experimental group and the weight changes made by the control group.

According to Hodgson and Knott (42) in a determination of the accuracy of live weights on dairy cows, when treating their data statistically, found that weighings of cattle on three successive days, the analysis of variance was 14 lbs. They also found that the Standard

dard

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dard Error in the weights of 1,200 lbs. cows was on the average 2.2 lbs.

It would therefore appear, that daily weighings on seven successive days would give a fairly accurate average weekly weight and this system was adopted. The difficulty of securing a weighbridge was finally overcome through the co-operation of the Waterloo Sugar Estate. Through old age and hard wear its accuracy had been somewhat impaired, the daily weights recorded probably being accurate to within a stone. Bearing in mind the possibility of body-weight variations of the order of 60 lbs. within two successive days, this inaccuracy, though undesirable and unavoidable, was not so serious as it might appear.

This was, however, by no means an ideal arrangement particularly in an experiment with dairy cows when constant supervision is essential and with the class of labour available leaving much to be desired. Had it been possible to keep the animals and run the experiment at the College Farm, continuous personal supervision would have been greatly facilitated. Such as it was, with the cattle housed at some little distance from the College, it was only possible to make periodic visits during the course of the day to supervise the milking, milk-recording and feeding. Visits were also made to supervise spraying operations; to make observations regarding the health and degree of tick infestation; to record the body temperatures of the individual animals and for the drawing of blood samples.

(ii) Selection of Experimental Animals.

All the animals selected for the experiment were, as has been stated, running with the commercial dairy herd at the Government Stock Farm. Since all the animals to be used were intended to be grade Holsteins, which are fairly numerous at the Stock Farm, a

certain

certain amount of selection was afforded. This Holstein (Bos taurus) breed was selected for such an experiment because of their susceptibility to tick infestation and since the native zebu (Bos indicus) breed are relatively immune to the tick, it was thought that an experiment of this nature would throw more light on the advantages and disadvantages of the Holstein breed as a dairy animal for the tropical farmer. Animals from this breed as near the average type as possible were to be selected. They should, for instance, conform to the average dairy type and be of the correct breed; non-pregnant or otherwise as near the date of service as possible and at least not more than half way through the lactation period in order to avoid the possibility of any animal drying off. They should also be of medium weight and age, in good health and possess good sound udders and teats. Only animals docile and easy to handle should be maintained; all refractory or nervous individuals being rejected. Therefore, with these points in mind, the next step was to examine the herd record books containing details of all cows. Unfortunately, owing to lack of staff and other difficulties experienced by the Stock Farm since the start of the war, the records of some of the animals had not been brought up to date. However, irrespective of this setback, it was possible to select a number of cows conforming, as near as possible, to the aforementioned principles. The next procedure was to examine the cows themselves and from them select the ones best satisfying the requirements of health, size, weight and temperament. By these methods and with close regard to the individual points, sixteen animals were selected for experimentation.

The records of the individual animals, as obtained from the record books of the Stock Farm are tabulated below:-

Table 1.

No.	Name	Breed & Origin Holstein:Zebu	Age in Years	No. of previous lactations in herd	Yld. of Lactation previous to Ex- periment (Lbs.)	Lactation Period (Days)	Daily Yield at start of Expt. (Lbs.)
1.	Baby	$\frac{5}{8}$ bred; bought	15	9	6820 lbs.	389	18
2.	Belle IV	$\frac{5}{8}$ "	7	3	5528	290	15.5
3.	Nymph III	$\frac{3}{4}$ "	5	2	4869	300	18.5
4.	Mathilda	$\frac{3}{4}$ "	5	2	5716	Still milking; sent to I.C.T.A. after 341 days	10.0
5.	Nancy Lovell II	$\frac{3}{4}$ "	7	2	3746	367	16.0
6.	Amelia II	$\frac{3}{4}$ "	9	4	3853	257	10.0
7.	Ruby III	$\frac{3}{4}$ "	5	1	4591.5	Still milking; sent to I.C.T.A. after 307 days.	14.5
8.	Josephine III	$7/8$ "	6	2	4250.5	363	16.0
9.	Crystalline	$\frac{5}{8}$ "	8	4	4949.5	329	14.0
10.	Laurie II	$\frac{5}{8}$ " bought	10	4	6634	336	17.0
11.	Isabella II	$\frac{5}{8}$ "	11	6	7919	445	18.5
12.	Soozee II	$\frac{5}{8}$ "	5	2	3847	370	11.5
13.	Electra	$\frac{5}{8}$ " bought	9	3	- ?	-?	14.5
14.	Amelia I	$\frac{1}{2}$ "	8	4	3165	344	16.5
15.	Shiama III	$\frac{5}{8}$ " bought	12	5	5515.5	411	17.0
16.	Jaiphallia III	$\frac{5}{8}$ "	6	3	5047.5	266	14.5
17.	Phoolwantia II	$\frac{5}{8}$ "	10	5	4287.5	323	22.75
18.	Gladys II	$\frac{5}{8}$ "	5	2	6540.5	416	16.0
19.	Jaiphallia IV	$\frac{5}{8}$ "	6	3	7044	617	16.0
20.	Cinderella	$\frac{5}{8}$ " bought	10	2	1744.5	176	8.5
21.	Crystal	$\frac{5}{8}$ " bought	4	1	3507	155	26.5
22.	Kimp.	$\frac{5}{8}$ " bought	10	5	5034	318	29.0
23.	Belle II	$\frac{5}{8}$ "	10	7	5970	490	12.5
24.	Moondaree	$\frac{5}{8}$ "	10	5	2336	229	16.0

(iii) Length of Trial Period.

In an experiment of this type where the reactions of two groups of animals are being compared it was essential that each group be producing, on the average, approximately the same amount of milk. To obtain this a trial period of 14 days' duration was carried out prior to the experiment proper in both the wet and dry seasons. During this period the animals were fed additional rations over and above their requirements for maintenance and production. The amount normally fed was 75 to 100 lbs. roughage, considered sufficient for maintenance, and 4 lbs. concentrates for every gallon of milk produced. The concentrate ration was increased daily until each animal was receiving 5 to 8 lbs. per day depending on her milk production. By the end of the fortnight each animal was producing her maximum amount of milk and from their daily milk yields two groups of animals were consequently selected, eight in each group, producing approximately, on the average, the same weight of milk.

During this preliminary period, all animals had the opportunity of becoming accustomed to their new positions in the byre and to their respective stalls and by the time the experiment proper started all the animals knew exactly where to go, with the consequent elimination of any harsh treatment on the part of the attendants. Fortunately the animals selected showed no sign of nervousness, all of them being of a docile and easily manageable disposition.

(iv) Housing and Feeding of Experimental Animals.

Since this experiment was primarily planned and designed to find out what effects a naturally acquired tick infestation had upon the dairy cow, everything possible was done to keep the animals under ordinary, daily routine management so that the results obtained would be

more applicable to the average dairy herd kept under the present system of management and environmental conditions existing in Trinidad. Consequently, the experimental animals were allowed the same amount of freedom as the rest of the dairy herd, no additional housing facilities, other than the byre being required.

The feeding of the animals was routine with the feeding of the rest of the herd; no particular attention being given to any individual animal concerned in the experiment. This proved very advantageous during the investigations, firstly, in that it was not necessary to make arrangements for special foods and feeding and secondly, it obviated the difficulties involved concerning the labour problem at that time. For maintenance ration, forage grass was fed as chop-chop up to 75 to 100 lbs. per day. Concentrates, of the mixture cited below, were fed as to the general herd, each animal receiving a definite quantity depending on the amount of milk produced and on the state of pregnancy. Water containing molasses up to 10 gallons per day was offered at noon together with the roughage part of the ration.

Table 2.

Rations for Experimental Animals.

Dry Concentrate Mixture

PARTS.

COCONUT MEAL	250
OIL MEAL	150
BRAN (WHEAT)	75
" (RICE)	100
FLOUR	100
PEAS	75
MINERAL MIXTURE	50

800

Fed

Fed as:- For maintenance 75 to 100 lbs. roughage
" production 4 lbs. concentrates per gallon of milk
produced.

FORAGE GRASS. This was variable and depended on which forage was available, Elephant grass, Guinea grass, Para grass or Uba cane fed as chop-chop in mixture with water containing molasses.

B. Description of the Trials.

(1) Plan of the Experiment.

These trials were designed to demonstrate the effects of the cattle tick on the dairy cow in the average dairy herd managed under the present system prevailing in Trinidad. This necessitated having two groups of animals, as near as possible, for all practical purposes, similar in regard to average weekly yield of milk, weight, size, breed etc. As has already been mentioned (see p. 21) 16 animals of average qualities were selected for these trials. One group of 8 cows were kept free from ticks during the experimental period and these constituted the check animals to a second group^{of} 8 tick-infested animals to which the results of this experiment are applicable. This trial was commenced in July 1944 at the beginning of the wet season, allowed to continue for a period of 10 weeks, and repeated in February 1945 at the start of the dry season. Both groups received the same management and attention, the only difference being that of subjecting the check animals to regular sprayings in an arsenical dip in order to keep them free of the parasite. Each cow received the same amount of feed, in proportion of course to her milk production and state of pregnancy. Feeding was done at the same time every day; all the animals

animals had access to the same water; were given the same amounts of water containing molasses and were allowed to graze the same pasture during the morning period up to mid-day. Both groups occupied the same line of stalls in the byre with a space of one empty stall for separation.

All the animals, as will be seen from the daily routine table, were fed concentrates three times each day and water containing molasses offered twice daily.

(ii) Records Taken.

(a) Milk Yields.

The daily milk yield was recorded in the case of all the cows. Milking, as will be seen from the daily routine table, was carried out in the morning at 7.00 a.m. and in the afternoon at 4.00 p.m. As far as was possible, personal supervision was given to this operation to ascertain that each animal was milked properly and that no milk remained in the udder. Seven milkers were available so that the entire process was completed in at most 75 minutes. The yield of milk produced by each animal was recorded in lbs. using a spring balance which had been previously calibrated so that the reading of the pointer was the actual weight of milk and did not take into account the weight of the milking pitcher.

(b) Weight.

Each animal was weighed on seven successive days at the beginning, the middle and end of the experimental period. The individual weights were recorded to show (1) what difference, if any, existed between the two groups and (2) if such existed, its magnitude could be easily determined.

It was only possible to carry out weight recordings during

the

the experiment period in the wet season, since the weighbridge was required by Waterloo Sugar Estate for the weighing of cane when the experiment was repeated in February.

(c) Blood Samples.

As has already been noted, due to lack of equipment at the inauguration of this work, it was only possible to analyse a limited number of blood samples. However, undesirable but unavoidable as this fact must be, samples were obtained and analysed at the start and at the end of the experimental periods both in the wet and dry seasons. These individual samples were analysed in an endeavour to determine (i) what effect a tick infestation had on the blood picture of the parasitised animal (ii) the nature of the effect and (iii) whether the haemoglobin indices and the red blood cells maintain a constant relationship.

The samples were analysed for their respective haemoglobin indices and erythrocyte counts.

(d) Temperatures.

The body temperatures were recorded from all the experimental animals at randomised periods throughout the course of the experiment in an attempt to detect any occurrence of fever.

(iii) Daily Routine.

For both trials, that is, wet and dry season trials, the daily routine was essentially the same.

6.00 a.m. All animals brought in. Cleaned out mangers in preparation for morning feed.

6.30 a.m. 1/3 concentrates fed + approximate $\frac{1}{2}$ water containing molasses i.e. 5 gallons.

7.00 a.m.

7.00 a.m. Udders washed. Milking commenced and quantity recorded.

8.30 a.m. Cows turned out to pasture. Cleaning, washing out of stalls and removal of dung.

9.30 a.m. On the appropriate day, after the 14 day interval, the tick-free group sprayed at this hour.

12.00 noon All animals brought in. $\frac{1}{3}$ concentrates feed + $\frac{1}{2}$ water containing molasses. Roughage as chop-chop feed.

3.00 p.m. Cows washed down: stalls washed and cleaned: dung removed. Mangers cleaned.

3.30 p.m. Remaining $\frac{1}{3}$ concentrate fed.

4.00 p.m. Cows milked and quantity recorded.

5.30 p.m. Cows turned out to pasture. Washing of byre and removal of dung.

C. RESULTS OF EXPERIMENTS.

(a) Fever Caused by Ticks.

The effect of tick infestation appears primarily to be one of inciting fever in certain of the experimental animals. Rectal temperatures were recorded in all animals in both the wet and dry seasons. These temperatures were taken at randomised periods throughout the course of the experiment and the results of such are shown, for the wet season in Table 3.

As will be seen from the Table, recordings were made on twelve separate days. All readings were taken at 2.30 p.m. with the exception of one reading taken at 9.00 a.m.

From the results recorded, it is observed that the average temperatures, in most cases, are above normal in both the tick-free and tick-infested groups. The average temperatures of the check animals are, on the whole, lower than the average temperatures of the

tick-infested

tick-infested animals. In the opinion of the writer, the reason for the check animals showing temperatures above normal may have been due to the moist, humid conditions prevailing at the time when the temperatures were taken. It would further appear that the amount or degree of fever caused by tick infestation is a fairly variable factor and seems to depend largely on the individuality of the animal. Amelia I, a cow of average size, became fairly heavily infected, particularly on the escutcheon, recorded an average temperature of 106.2°F , while Laurie II similarly affected recorded an average temperature of 103.7°F . Jaiphallia III, fairly lightly infested shows an average temperature below most of the animals in the tick-free group.

In Table 4 are set out the temperatures recorded during the dry season. The results obtained are in most respects similar to those recorded during the wet season. Both groups show average temperatures above normal. In the case of the tick-infested group a mean temperature of 103.7°F is recorded as against 103.1°F in the wet season. The relative degree of tick infestation was manifestly more acute in the dry season and this might account for the small increase in the mean temperatures. The checks, in the wet season, recorded a mean temperature of 102°F and 102.1°F in the dry season. It appears, therefore, that tick infestation has a tendency to an increased rise in temperature in an infested animal, the amount or degree of fever being a variable factor depending largely on the individuality of the animal itself, although the higher mean temperature of the tick-infested animals in the dry season over that obtained in the wet season might have been due to the fact that, on the whole, milk production was at a higher level in the dry season. This would have the effect of increasing the metabolism of the animals and hence increasing the body temperatures.

Table 3.

Temperature records of experimental animals at various periods and averages of readings in °F in
WET SEASON.

Cow	Degree of Infestation	July 20th p.m.	July 28th p.m.	Aug. 3rd p.m.	Aug. 7th p.m.	Aug. 17th p.m.	Aug. 18th p.m.	Aug. 28th p.m.	Aug. 29th p.m.	Aug. 30th p.m.	Aug. 31st p.m.	Sept. 1st p.m.	Sept. 2nd a.m.	Average Reading F
Belle IV	Free	102.0	101.5	102.5	101.0	103.0	102.5	103.0	103.1	102.0	102.0	102.0	101.0	102.1
Josephine III	"	102.5	102	103	101	102.5	101	102.5	103	102.1	103	102	101.2	102.2
Amelia II	"	102.4	103	102.2	102	103	101.5	102.4	103	101.0	101.0	103	102	102.2
Nymph III	"	101.2	102	101.4	101	102.2	101.0	102	102	101.2	101	101.2	101	101.6
Mathilda	"	102.5	103.4	101.2	102.2	102.6	101.6	103.2	103.1	101	101	102.1	102	102.1
Ruby III	"	101.5	101.0	101	101.4	102	101.6	101	102.1	101	101	102	101.2	101.6
Baby	"	103	104	102.2	102	101.6	101.5	103.1	103.2	101.2	101	102	101	102.2
Nancy Lovell II	"	102.5	103	103	102	101.5	101.2	103	103	101	101	102	102	102.1
Electra	Moderate	103	104	103.5	102	104	104	102	102.1	102	102.5	102.3	102	102.8
Laurie II	Fairly Heavy	104.5	105	104.5	103.2	102.6	105.0	103	104	102	102.5	103	105	103.7
Shiama III	Moderate	102.5	101.6	103	104	105.2	105	103	102	103	102.2	101.6	102.4	102.8
Isabella	"	103.2	102.1	102	103.2	103.1	101.2	102.2	102	102.2	102	101.2	102.3	102.2
Soozee II	"	101.2	102	102.2	103	101.2	102.2	101.4	103	102.1	101	103	102	102.0
Jaiphallia III	Fairly light	102.1	101.5	101	101.1	102	101.5	102	102	102.1	101	102	101.5	101.7
Amelia I	Fairly heavy	103	101.6	102.8	105.1	106	105.1	104.3	104.1	103	105.2	104	105.6	106.2
Crystalline	Moderate	105	104.6	105.6	102.8	104.8	105	103	104.1	102	103	101.2	102	103.6

Table 4.

Temperature records of experimental animals at various periods and averages of readings in °F in

DRY SEASON.

Cow	Degree of Infestation	Mar. 5th p.m.	Mar. 6th p.m.	Mar. 7th p.m.	Mar. 8th p.m.	Mar. 9th p.m.	Mar. 10th p.m.	Mar. 27th p.m.	Mar. 28th p.m.	Mar. 29th p.m.	Mar. 30th p.m.	Mar. 31st a.m.	Apr. 2nd p.m.	Average Reading °F
Jaiphallia III	Free	102.2	102.2	101.8	103.6	101.6	101.8	102.4	102	101.5	101	101.8	103	102.1
Laurie II	"	103.2	102.5	102.2	103.1	101.4	102.4	101.6	101.4	102	101.6	101	102.8	102.1
Isabella	"	102	102.4	103	102.6	102.1	101.4	101.2	101	103	102.2	103	103.5	102.3
Soozee II	"	102.6	102.2	103	101.2	103	102.8	103.2	103.1	101.8	102	102	103	102.5
Amelia II	"	103.5	103	102.5	102.5	102.2	102.2	101.8	103.2	103	102.8	103.8	103	102.8
Phoolwantia	"	101.1	103	102.6	104.5	102.8	101.2	102.4	103.4	102.6	102.6	102	101.2	102.5
Gladys II	"	103.2	102.8	101.6	103.4	104	102.8	102	101	101.2	101.1	102.4	102	102.3
Shiama III	"	102.4	102	102	102.2	103	102.8	101.4	103.5	103	102.6	103	102	102.3
Moodaree	Moderate	103.6	104	102.8	102	103	102.8	102.6	103.4	103.6	104	104.5	103.2	103.3
Belle II	Fairly Heavy	103	103.2	102.6	102.4	105	105.5	106	105	104.5	106	104.2	105.1	104.3
Kimp	Fairly Heavy	104.2	103.8	103.6	104.2	105.1	105	105.4	106.1	106	105.8	104.6	104	104.8
Baby	Fairly Heavy	103.2	103	102.8	102	102	103.1	104	104.6	105.3	105	104.8	105	103.7
Crystallie	Moderate	104.0	104	103.6	102.1	102	102	101.8	101.6	103	102.8	104	104.5	102.9
Crystal	"	102.8	102	103.2	103.2	103	104.1	104.4	103.8	103.1	102.8	103.2	103	103.2
Cinderella	"	103.2	103.4	102.8	102.6	102.6	103.4	104.2	104.5	104	103.6	102.6	103.1	103.3
Jaiphallia IV	"	104.1	103.2	103	103.2	102.5	102.6	104.0	103.8	104.5	105.1	105.8	106.1	104.0

(b) Effect of Tick Infestation on Milk Production and Body Weights.

The milk yields of both the tick-free and tick-infested animals were recorded daily during the course of the experiments in the wet and dry seasons respectively. The following tables contain the summarised data of these daily milk yields recorded during the periods mentioned above. For fuller details relative to each individual animal see Appendix III. Unfortunately weight data of the experimental animals could only be recorded during the trial period in the wet season, since the weighbridge, on loan from Waterloo Sugar Estate, had to be returned for use during the cane harvest at the time when the dry season trial commenced. This difficulty might have been overcome by having the animals brought from the Stock Farm to the College Farm daily and the weighings of the sixteen animals recorded for 7 successive days. This alternative was objectionable for two reasons. In the first place, the Stock Farm authorities did not approve of sending their animals away some considerable distance from their own premises for such a purpose, and in the second place, the moving of the animals about for weekly periods at the start, at the middle and at the end of the trial would be quite enough to upset them and make them scour badly, besides dropping their milk yield. If this had taken place in an experiment of this nature, the subsequent milk yields recorded could not possibly have conveyed the true state of affairs and for this reason the idea was abandoned. Undesirable, but unavoidable as this was, the writer was compelled to forego the recording of weight data in the dry season, as Table 8 shows.

It must also be pointed out that during the dry season trial, one animal, Shiama III, aborted three weeks after the experiment had commenced. Although she did not entirely dry up, this miscarriage had the effect of slackening her milk yield fairly considerably. Therefore, as a result, the group records (Table 7) by weekly periods of the tick-free animals are not as high, on the average, as they might have been.

Table 5.

*Group Records of Experimental Cows by 7-day Periods.

W E T S E A S O N

7-day period ending:	Average Milk Production in lbs.	
	TICK FREE	TICK INFESTED.
8th July	99.3	98.2
15th "	96.9	97.3
22nd "	92.8	97.7
29th "	91.8	97.2
5th August	95.5	92.5
12th "	88.7	84.8
19th "	88.3	77.5
26th "	79.2	73.2
2nd September	74.7	66.2
9th "	76.5	67.5

*For individual records of experimental cows by 7-day periods see Table 17 in Appendix.

Table 6.

Effect of Tick Infestation on Milk Production
and Body Weights of Cows.

W E T S E A S O N.

	MILK PRODUCTION IN LBS.			BODY WEIGHT IN LBS.*			
	Aver. for 1st 7-day period	Aver. for last 7-day period	Average Decrease %	Aver. for 1st 7-day period	Aver. for middle 7- day period	Aver. for last 7- day period	Aver. Increase %
TICK FREE	99.3	76.5	22.9	834.8	836.3	871.2	4.4
TICK IN- FESTED	98.2	67.5	31.2	842.5	838.3	866.9	2.9

*For individual daily weights of all animals see Tables 14/ ^{15 & 16} in Appendix

Table 7.

Table 7.

* Group Records of Experimental Cows by 7-day Periods.

D R Y S E A S O N

7-day period ending:	Average Milk Production in lbs.	
	TICK FREE	TICK INFESTED
24th February	112.5	110.1
3rd March	112.2	106.4
10th "	113.2	102.7
17th "	109.1	105.7
24th "	117.2	109.3
31st "	103.4	105.7
7th April	96.8	90.2
14th "	99.0	92.8
21st "	95.0	79.3
28th "	93.0	79.2

* For individual records of experimental cows by 7-day period see Table 18 in Appendix.

Table 8.

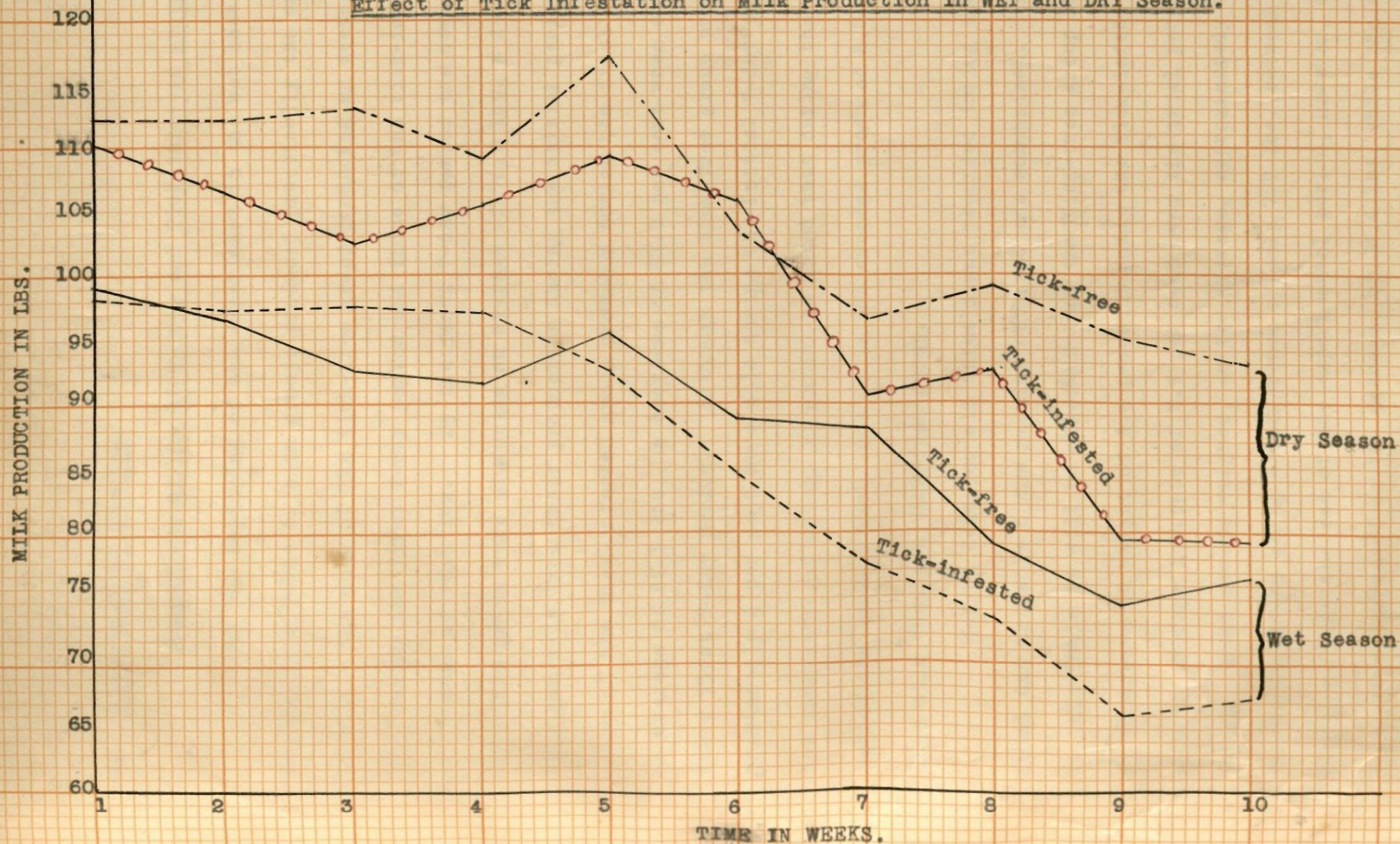
Effect of Tick Infestation on Milk Production
of Experimental Cows.

D R Y S E A S O N.

Group	MILK PRODUCTION IN LBS.		
	Aver. for 1st 7-day period	Aver. for last 7-day period	Average Decrease %
TICK FREE	112.5	93.0	17.3
TICK INFESTED	110.1	79.2	28.1

GRAPH NO. 1

Effect of Tick Infestation on Milk Production in WET and DRY Season.



D. Discussion of Results.

Comparison of the Tick-free and Tick-infested groups.

At the beginning of the experiment in the wet season, as will be seen from Table 5, both groups produced practically the same amount of milk - the cows of the tick-free group producing an average of 99.3 lbs. during the first 7-day period and those of the tick-infested group an average of 98.2 lbs. By the final 7-day period the cows of the tick-free group were producing an average of 76.5 lbs., a decrease of 22.9 per cent from their production during the initial period, while those of the tick-infested group produced during the final 7-day period an average of 67.5 lbs., a decrease of 31.2 per cent when compared with their first 7-day period. Although the tick-free group produced approximately 1 per cent more milk during the initial 7-day period than the tick-infested group, it should be noted that during the final 7-day period the tick-infested group, on the average produced 8.3 per cent less milk than the tick-free group.

Weight data for all animals was recorded during the wet season trial and in Table 6 the results obtained are summarised. By reference to this Table it will be observed that the tick-free group shows an average increase in weight of 4.4 per cent while the tick-infested animals show an average increase of 2.9 per cent over the trial period of 10 weeks. Both groups weighed, on the average, approximately the same at the start, there being a difference of only 7.7 lbs. between the group averages. By the end of the experimental period, however, the tick-free group increased on the average, by 36.4 lbs. while the tick-infested group increased by 24.4 lbs. This weight data, collected over so short a period as 10 weeks, does not demonstrate results from which a decisive conclusion could be drawn, but it does suggest that tick-infestation

has

has a retarding effect upon the normal growth and bodily increase of affected animals.

The results of the trial carried out in the dry season are given in Tables 7 & 8 and the effect on the milk production represented graphically in Graph No. 1. The results obtained were observed to follow a similar trend to those obtained during the wet season trial, but in a more conclusive form. Again, both groups produced practically the same amount of milk at the beginning of the trial - the cows of the tick-free group producing an average of 112.5 lbs. during the first 7-day period and those of the tick-infested group an average of 110.1 lbs. During the final 7-day period the cows of the tick-free group were producing an average of 93.0 lbs., a decrease of 17.3 per cent from their production during the initial period, while those of the tick-infested group produced during the final 7-day period an average of 79.2 lbs., representing a decrease of 28.1 per cent when compared with their first 7-day period. Although there was a slight difference, on the average, of 2.4 lbs. of milk between the two groups at the start of the trial, it should be noted that during the final 7-day period a difference of 13.8 lbs. of milk, representing a percentage difference of 10.8% existed between the two groups. The degree of tick-infestation in the dry season experiment was, on the whole, heavier than that in the wet season. The effects of such a difference are clearly reflected in the results, when, by reference to Tables 6 & 8 it will be observed that during the wet season for the final 7-day period average, the tick-infested animals produced 9 lbs. less than the tick-free animals and in the dry season, the tick-infested group produced 13.8 lbs. less milk than the check cows over a similar period of time and under the same conditions of management, feed etc.

The main inference that can be drawn from such results is that milk yield in dairy cows is considerably reduced by tick infestation and, as has been shown, bears a direct relationship to the degree and intensity of such a parasitism. Unfortunately, weight data could not be recorded during the dry season trial for want of a weighbridge. This state of affairs was unavoidable, but the writer feels, due to this, that a considerable amount of information has been forfeited; information that might have proved to be more suggestive than that obtained during the wet season, when the degree of tick-infestation was not so intense.

On statistical analysis, the differences in yield were found to be non-significant. This may have been due to the small number of animals used in the experiments.

9. Effect of Spraying in an Arsenical Solution upon the Yield of Milk.

As has already been stated (see p.16) the check or tick-free group of animals were maintained free from the parasite by regular 14-day sprayings in a solution of Cooper's Cattle dip. Each animal was passed through the spraying machine twice so that thoroughness of wetting and treatment of the entire body surface was effected, Never at any time during the course of the experiment in the wet season were ticks visible on the bodies of the animals. In the dry season, when the prevailing conditions were optimum for increased infestations, odd ticks were visible. These ticks, however, were never allowed to reach maturity and since they were relatively few in number no appreciable damage appeared to be done.

From the Graphs Nos. 2 & 3, it is observed that spraying in an arsenical solution does have a deleterious effect on the milk yield. All the experimental animals were sprayed at the start of the experiment

and

GRAPH NO. 2.

Effect of Spraying in an Arsenical Solution upon the Yield of Milk - all 16 Experimental Animals.



and Graph No. 2 shows conclusively the acute decrease in milk yield. From an average, over 16 cows, of 234 lbs. of milk produced on the day of spraying to an average of 208.5 lbs. on the following day, it can be deduced that the dipping process, together with the disturbance and inconvenience experienced by the animals does show effects of paramount interest in so far as the milk yield is concerned. The cows, after this initial spraying, took four days to regain the former average figure of 234 lbs. This drop of 25.5 lbs. during the course of one day represents a decrease of 10.9% in the yield of milk. Graph No. 3 represents the respective yields of milk obtained after subsequent sprayings carried out during the course of the work. From the graphical representation of the results it is obvious that the decrease in milk yield was not so acute as that obtained after the initial spraying. The animals appeared to become more accustomed to the operation consequently causing them less inconvenience and disturbance, hence the milk yield did not suffer so appreciably and as they became accustomed to this treatment, the work of spraying was performed much more efficiently and much more quickly than on previous occasions.

The following table shows results obtained:-

Table 9.

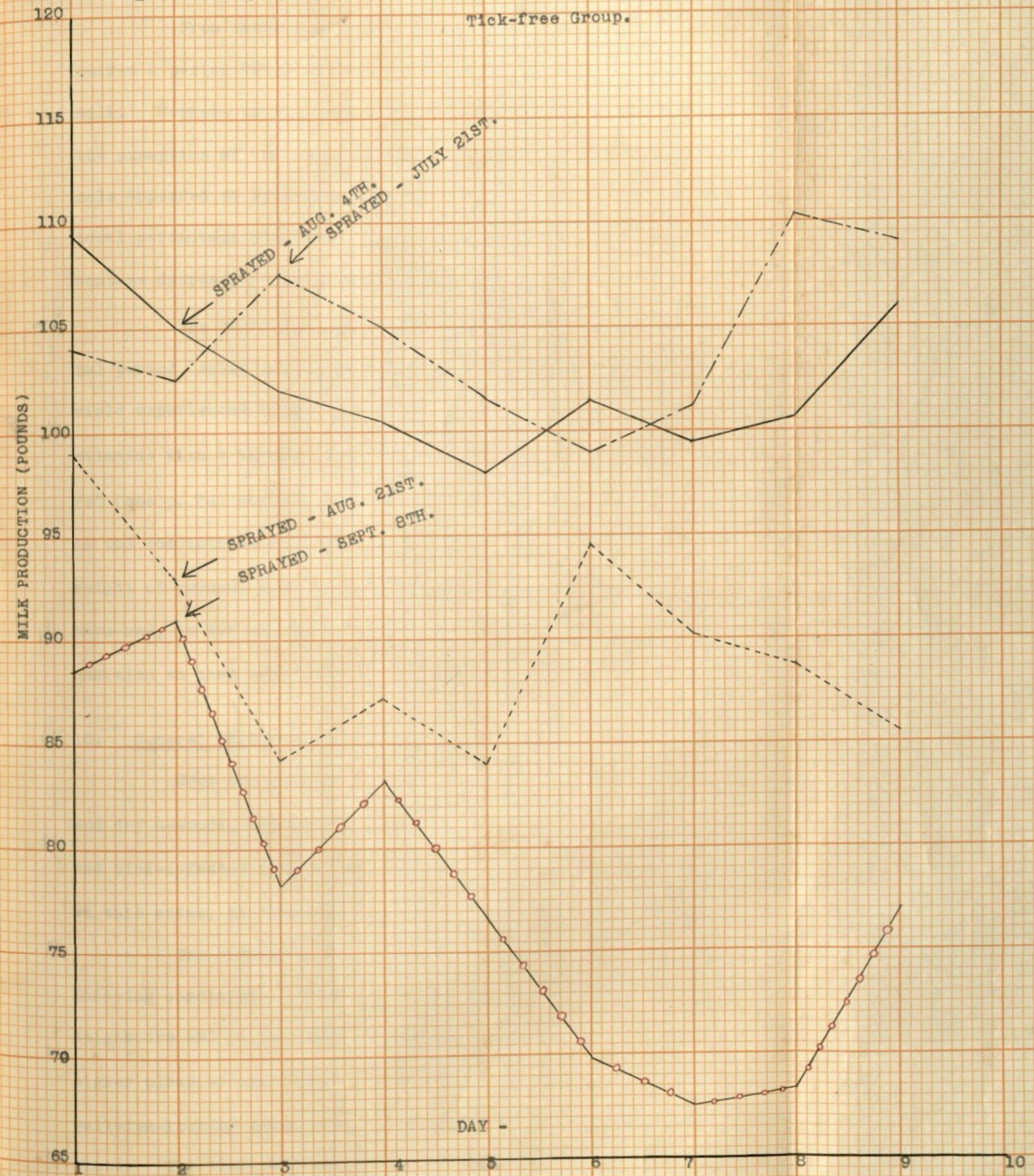
TICK FREE GROUP.
Average Milk Production in LBS.

Date of Spraying	Yield on day of spraying	Lowest Yield recorded before increase observed	Total %age decrease	No. of days taken to regain former yield of milk production
4/7/44	234	208.5	10.9	4
21/7/44	107.5	99.0	7.9	5
4/8/44	105.0	98.0	6.7	7
21/8/44	93.0	84.0	9.6	4
8/9/44	91.0	78.3	13.9	7

From

GRAPH NO. 3.

Effect of Spraying in an Arsenical Solution upon the Yield of Milk of Tick-free Group.



From these results, it will be observed, that the animals required a period varying from 4 to 7 days to regain their normal yield of milk. Workers in the United States (5) recorded similar results. With the exception of the last spraying, the other results show that the animals appeared to be becoming more accustomed to the operation, when the total percentage decrease in each case is compared with the total percentage decrease after the first spraying.

The last spraying carried out towards the end of the experimental period, shows even a greater decrease than the decrease in the milk yield experienced after the first spraying, but this spraying happened to coincide with a change in the feed of the animals. The normal ration fed (see p. 24) contained 250 parts by weight of coconut meal. The change in the concentrate ration was brought about by substituting 100 parts by weight of coconut meal by an equal amount of soya bean meal. This may have had, in the writer's opinion, some influence on the milk yield in addition to that caused by the spraying solution.

10. General Observations on Experimental Animals.

Over the course of these experiments conducted in both the wet and dry seasons, the external effects shown by the respective tick-free and tick-infested groups were plainly manifested. It is convenient, at this stage, to discuss the effects on the individual groups.

The tick-free animals, as a whole, appeared to be in a healthy, thriving condition. They appeared much more active than their parasited neighbours and at the same time giving the impression of being on a much higher plane of nutrition. Their coats assumed the characteristic well-fed-looking sheen which is associated with animals in a thriving state. The tick-infested group, on the other hand, appeared dejected

and

Fig. II.



Amelia I showing fairly heavy
infestation of mature female
ticks on escutcheon, root of tail
and around the external genitalia.

and inactive. Their coats were "shaggy" and appeared to have lost all bloom, in addition to their skins being dry and hidebound. Having lost appearance bodily, they looked thin and somewhat emaciated. The observance of the fact that more flies seemed to be attracted to the tick-infested group than to the tick-free group brought up a point of immediate interest. This fact was presumably due to the smell and bodily condition of the animals.

On individual observation regarding the tick-infested animals a comparatively wide range of conditions was noted. The degree of tick infestation ranged from fairly light to fairly heavy. Amelia I (Fig. 2) and Laurie II each acquired a fairly heavy infestation while Jaiphallia III under the same conditions was, at the end of ten weeks, lightly infested. Her bodily condition was good throughout the experiment and she appeared to be more able to resist tick infestation than some of the other members of the group. Whether this faculty can be attributed to her coat colour or not, it is hard to say. The writer is of the opinion that her coat colour, which showed a predominance of white hair to black, was probably partly the reason for such a relatively low degree of infestation. It was generally observed among this group that animals possessing a black coat colour were more susceptible to ticks. Those animals that were fairly heavily infested showed a greater proportion of black hair to white. These animals not only showed an abundance of ticks on the hind regions and around the external genitalia, but also along the flanks where sufficient shelter was afforded by the long hair. The other animals suffering from a moderate infestation did not seem to be appreciably distressed although they did present the appearance of loss of bloom.

All the infested cows appeared inconvenienced and upset by these ticks, due mainly to their irritating effects on the skin while sucking blood. It was a common occurrence for the animal to turn round and lick the affected parts with the tongue in an attempt to dislodge the ticks. Blood was observed to drop from tick wounds on cows, Amelia I and Laurie II. This condition attracted the Screwworm (Cochliomyia macellaria) and consequently secondary infection by these larvae was observed. Comparatively large sized larvae were abstracted, using forceps, from such tick wounds by the writer.

These maggots had a debilitating effect upon the host, in addition to destroying the tissues that they infested. On examination, they were observed to bore deep into the flesh, exposing an ugly wound, the smell of which attracted other flies, the commonest being the house fly (Musca domestica) and Stablefly (Stomoxys calcitrans). The Screwworm larvae were picked out and the wound treated with antiseptic. This is one reason why hand-picking of ticks from infested animals should be discouraged. If such a method must be employed, some disinfectant should be applied, for example, Jeyes Fluid as Saunders (8) suggests.

During the dry season experiment, as has already been pointed out, where the degree of tick infestation was more pronounced, similar effects to those discussed for the wet season were observed, but noted to be considerably more obvious. The divergence in appearance of the two groups was more accentuated and the fairly heavily infested animals, Belle II, Kimp and Baby appeared to be appreciably distressed both regarding feedings and frequency of respirations. Of these animals, Belle II appeared to be the most noticeably distressed and as many as 128 fully engorged, mature female ticks, attached to the body surface, were counted. These animals again showed a marked predominance of black coat colour over white coat colour and from these observations the writer is of the opinion that

that tick immunity in animals (11) is not only an acquired character but it also appears to depend largely on the phenotypic characteristics exhibited by the animal itself.

11. Summary and Conclusions.

1. A study of the effects of the Cattle Tick - Boophilus annulatus Say - upon the dairy cow under Trinidad conditions is herein reported.
2. This species of tick has a decidedly injurious effect upon dairy stock, the extent of the injury being, in the main, largely dependent upon the degree of infestation, as was shown during the dry season trial.
3. The effect is more obvious upon the milk production than upon the body weights. At the start of the trial in the wet season the tick-free and tick-infested groups produced, on the average, practically the same amounts of milk. By the end of the experimental period, the tick-infested group produced 31.2 per cent less milk than they did at the start of the trial. Similarly in the dry season, both groups produced practically the same amounts of milk during the initial 7-day period, - but by the final 7-day period the tick-infested group produced 28.1 per cent less milk than they did at the start of the trial.
4. During the 10 weeks experiment in the wet season the tick-free animals gained 4.4 per cent in body weight while the tick-infested gained 2.9 per cent.
5. Individual resistance of cattle to tick infestation is a variable character.
6. A certain degree of fever was found to be present in some animals at various periods during the course of the experiment. This finding was more marked in the dry season when tick infestation was considerably more intense, although it was found that the amount of fever

shown

shown did not necessarily bear any relationship to the degree of tick infestation. Thus, it would appear that the nature and individuality of the animal is concerned in the amount of fever recorded.

As will be seen from Graph No. 1, however, the milk production was, on the whole, at a higher level during the dry season. This would have the effect of increasing the metabolism of the animals and hence increasing the body temperatures. This would appear, in some measure, to account for the variation in the temperatures recorded.

7. Because of irritation and inconvenience incited in the parasitised animal, together with the other findings during the course of this work, the tick is a serious impediment to the development of the dairy industry.
8. Spraying, parasitised animals, in an arsenical solution, causes an acute, though temporary, decrease in milk production.
9. Since the period of experimentation was comparatively short, it is difficult to draw up any definite conclusions, but from the results obtained, due to naturally acquired infestations of ticks, it would appear that considerable losses are experienced, and such results point out the need for constant control measures against what appears to be one of the tropical dairy farmer's worst enemies.

Part II.

Haematological Studies of the Experimental Animals.

1. Introduction.

Dairy animals, especially Bos taurus types, are fairly heavily parasitised in the tropics. There is a constant struggle between the host and the parasite. Existing methods of control of these ecto-parasites, the chief of which being the Cattle Tick, are fairly effective, but due to irregular and all too infrequent applications of the remedy, the host appears to suffer, in no small measure, from their ravages.

Workers in the States (5) pointed out that the blood of certain animals, similarly parasitised, appeared to be thin. This, immediately indicated that the tick might have some destructive effect upon the cellular components of the blood. The parasite during its life cycle spends approximately 18 days on the host. Over this period it is a continuous feeder; all the stages in reaching maturity being effected on the host, therefore, it follows that a considerable quantity of blood must inevitably be sucked from the host and utilised in the digestive tracts of the parasite.

According to Mayer (9) in an article published by the U.S. Department of Agriculture, a replete female tick weighs about 5 grs., so that 1,500 ticks of average size will weigh 1 lb. Approximately all this weight consists of blood drawn from the host during 3 to 4 days, the period of final engorgement of the tick. The present writer found that roughly 25 engorged female ticks suck approximately 4 ccs. of blood. This amount was measured by squeezing all the contents of the ticks. Therefore, if an animal is fairly heavily parasitised,

harbouring

harbouring say 3,000 ticks, the blood extracted from the host will be roughly 120 ccs. Where infestations are continuous, the withdrawal of blood is likewise continuous.

Neal and Becker (28) working in Florida with normal cattle and cattle suffering from "Salt-Sick" disease found that there were marked differences between the two sets of animals. In the normal animals the Hb. values ranged from 10.94 to 11.06 grs. per 100 mls. of blood and in the sick animals 4.81 to 9.04 grs. per 100 mls. of blood. They further stated that in very anaemic animals the values may be as low as 3.02 grs. per 100 mls. of blood.

Burnett (32) stated that the blood is a peculiar tissue in that it is in intimate relation with practically all other tissues of the body, bringing substances to them and carrying away other substances.

From these findings, by the workers cited above, interest was stimulated to endeavour to find out some facts regarding the blood picture of animals, suffering from a natural infestation of ticks.

2. Review of Literature.

The literature in reference to the haematological aspect of this work is all fairly recent and the main sources of such work actually done in the tropics are the Philippines and India. Considerable amount of work has been done in the States on the blood picture and blood composition of domesticated animals. After an exhaustive search of the literature, no reference was found dealing with the blood analysis of tick-infested ^{animals.} Woodward and Turner (5) 1915 state that the blood of some of the tick-infested animals in their experiment was observed to be thin.

However,

However, a review of the available literature on this aspect of blood analysis is not out of place here, since it has a direct bearing on the nature of this work. For haemoglobin estimations, the writer used the Sahli haemoglobinometer which is essentially an acid haematin method using a standard containing the same colouring matter as is present in the tube containing the blood. It was pointed out by Berczeller (35) and by Wu (36) that the colour developed in the acid haematin method is affected by non-haemoglobin substances in the plasma. Wu introduced his alkali haematin method to avoid these. Ponder (24) deals with the nature and magnitude of these errors in an article published in 1942. In this work the materials used were either whole human blood or packed human red blood cells, the packing being carried out by spinning for 2 hours at 4000 R.P.M. and the plasma thereafter removed. The determinations of Hb. were made at room temperature by the acid haematin and alkali haematin methods. The results obtained were compared with the results of Hb. determinations made by Wong's (37) Iron method, assuming the iron content of Hb. to be 336 mg. per cent.

According to Ponder, the results obtained show that the Sahli acid haematin method and the Wu alkali method give results for Hb. content of whole blood which are often in poor agreement with the results, by Wong's iron method. He further states that the principal sources of error are the long and variable time required for the full development of colour in the haematin methods and to the fact that the plasma and cells both contain substances other than Hb. which affect the final colour.

Work

Work at the Minnesota Experiment Station carried out by Kemp (18) 1933 on the use of blood anti-coagulants, led the author to conclude that, while it is possible to use blood oxalate mixture for making the various examinations included in a blood picture, the results are likely to give values that are significantly greater or less than the blood picture obtained from freshly drawn blood. From his studies, the writer concluded that, as the interval of time increases between the drawing of the blood and the making of examinations, there is a tendency for the Hb. values to increase and the total number of red cells per *mm.* of blood to increase. He further states that this finding showed no indication of uniform application to any given sample of oxalated blood. In this work by the present writer, the above facts were observed to take place and as the Hb. value increased the erythrocyte count also increased. Not only are Hb. values and red cell counts affected by blood preservatives but also by the influence of atmospheric temperatures upon the animal itself. Work by Manresa et al. (31) 1940 in the Philippines found average values of 9.43 to 9.87 grs. per 100 ml. of blood in native breeds and 6.76 to 6.88 g/100 ml. in Herefords and Holstein-Friesians imported from U.S.A. They considered that the high temperature and humidity of the district tended to lower the Hb. values and erythrocyte counts of imported pedigree cattle.

Workers in India (19) studying the composition of the blood of farm animals there, found that the values for red cells, white cells and Hb. were highest in young animals and decreased with age. The figures quoted are for erythrocytes: 11.6 and 8.1 millions/*mm.* of blood for growing and adult animals respectively. In the case of Hb. the average values were 14.6 and 10.9 grs/100 ml. of blood for young and adult animals respectively.

Sankaranarayanan (30) reports that from a study of the blood of Indian dairy animals, the erythrocyte count of pure Indian cattle is far above those in the Ayrshire bull and the half-bred cows. He quotes a mean figure of 7.5 to 9.6 mill./ cmm. of blood, while the figure for the buffalo was the highest, that breed averaging 9.6 mills./ cmm. of blood. Fraser (34) 1931, working in Cambridge, gives under 7 mills. as the average count for British cattle, while the American figure of 6.6. mills. as reported by Nicols (33) 1935 agrees with that of Fraser. The same writer quotes figures in Australian cattle, for red cell counts; the average number being 7 to 10 mills./ cmm. of blood. It will be observed that the figures given for Indian cows agree with the figures given for Australian cattle.

Allcroft (20) working on the Hb. level of cows and sheep in England and Wales, states that the blood of the two groups is very similar, having a mean value around 11.5 g/100 mls. He further states that metabolic disorders such as "milk-fever" and "grass tetany" in cows and "pregnancy toxæmia" in ewes have no effect on the Hb. level. Anderson et al. (21) 1930 found Hb values of female cattle to be higher than those of male. Mc Cay (22) 1931 stated the opposite, mean values being 10.9 g/100 mls. of blood for cows and 12.89 grs/100 mls. for bulls. Brooks and Hughes (29) 1932 in a study of 355 samples from 297 dairy animals found a mean of 10.96 grs/100 mls. and stated that age, breed and prolonged fasting did not influence blood Hb. Miller (23) 1932 reported a range of 9.9 to 14.2 g, average 12.09 for adult cattle and a range of 9.6 to 18.1 grs/100 mls., average 12.0 grs. in younger cattle. These figures are in fair agreement with those of Mullick and Pal (19) for cattle in India.

Manresa and Reyes (25) 1934 report that the amount of Hb./100 mls. of blood in Indian Nellore was 9.87 grs. Manresa, Gomez and Santos (26) 1939 working with Nellore cattle determined the variation of Hb. during the course of 24 hours for a period of seven days, and found the Hb. indices to be highest during the morning and late in the evening and lowest at noon. They reported the average Hb. to be 10.17 grs./100 mls. of blood.

Neal and Becker (28) 1933 working in Florida on the variations in the Hb. content of cattle at intervals of $2\frac{1}{2}$ hours, claimed that the best time to get samples for uniformity was 1.30 p.m. Samples taken at 8.30 a.m. were next in uniformity to those taken at 1.30 p.m. The same workers also found, working with normal cattle and cattle suffering from "Salt-Sick" disease in Florida that there were marked differences between the two sets of animals. In the normal animals the Hb. values ranged from 10.94 to 11.06 grs./100 mls. of blood and in the sick cattle 4.81 to 9.04 grs./100 mls. of blood. They further stated that, in very anaemic animals, the values may be as low as 3.02 grs./100 mls. and a value as low as 1.37 grs./100 mls. of blood had been recorded shortly before death.

Burnett (32) 1917 stated that the blood may be considered as a tissue composed of cellular and intercellular substances. The fluid portion is considered by him as the intercellular substance. He further stated that the blood is a peculiar tissue in that it is in intimate relation with practically all other tissues of the body, bringing substances to them and carrying away other substances.

The above statement is further borne out in the fact that so much work has been done on blood and the present writer feels that enough has been said, in the foregoing review, to emphasise the necessity of still more expansion in this field, dealing more particularly with the blood composition and blood picture of livestock in the tropics.

3. Objects of the Experiment.

The objects of the experiment were (a) to find out if any difference existed in the blood composition between animals parasitised by the Cattle Tick - Boophilus annulatus Say - and animals that were freed and kept free of this parasite. (b) to find out what differences, if any, existed in the blood examinations made during the wet and dry seasons respectively and (c) to find out the nature and magnitude of these differences, if any.

Owing to lack of equipment and other facilities, in the College, when this work was commenced, it was only possible to carry out blood examinations at the beginning and at the end of the experimental period. In the case of the tick-infested group, after they had been freed of the parasite at the end of the experimental period, a recovery period of 4 weeks duration was carried out and the blood of each animal analysed again.

4. Technique of Blood Sampling.

For routine blood examinations, samples are normally obtained by venepuncture with a hypodermic needle. Where the examination can be done on the spot, it suffices to obtain the blood from a skin puncture. Since it was impossible to do the examinations on the spot, the writer employed the former method of drawing samples in this work. The samples were obtained by puncturing the jugular vein with a sterile hypodermic needle. It is important for this operation not to excite the animal unduly, otherwise erroneous or inaccurate results may be obtained, therefore the most secure position of holding the animal is of the greatest importance. This was accomplished by passing a strong rope over the horns and round the nose, while at the same time drawing the animal's

head

head to one side and affixing the rope firmly to the stanchion at the side of the stall. The animal was prevented from moving backwards because of the neck yoke and the iron standards at each side of the stall only offered a limited space in which she could move her body. To still further decrease the animal's chance of moving about too much and therefore becoming too excited, an assistant held the nose. A narrow rope was then passed round the animal's neck and drawn tight to effect partial stasis and consequently make the vein stand out visibly in order to facilitate the insertion of the needle. The skin was then treated with antiseptic, in this case 70 per cent. alcohol, and the needle inserted with a quick deliberate stab. Where the blood could only be obtained by pushing and squeezing, a fresh insertion of the needle had to be made. Once the blood was observed to run freely from the needle, the sample, approximately 5 ccs., was collected in a test-tube, containing .5 ccs. of Potassium oxalate to inhibit the coagulation of the cellular components of the blood.

These samples, for analysis, were drawn in the morning between 8.30 a.m. and 9.00 a.m. Neal and Becker (28) 1933 in Florida working on the variations in the content of cattle at intervals of $2\frac{1}{2}$ hours, found that the best time to get samples for uniformity was 1.30 p.m. They further point out that samples taken at 8.30 a.m. were next in uniformity to those taken at 1.30 p.m. When it was not practicable to carry out the analysis immediately after drawing the blood, the samples were kept in cold storage.

5. Apparatus and Methods Used in Blood Analysis.

At the time of commencement of this work in July, 1944, no apparatus was available in the College for the determination of Hb. and red cells in the blood, but through the co-operation of Dr. Pawan the writer was able to utilise the apparatus and other facilities at the

Government Bacteriological Laboratory in Port of Spain. The quota of samples constituting the day's work were taken in the morning; the writer then travelling into Port of Spain to carry out the respective blood analysis.

The determinations for haemoglobin were done using the Sahli haemoglobinometer (43) and later when apparatus was procured by the College the Sahli-Hayden haemoglobinometer. Sahli's haemometer uses as a standard a tube containing a fluid coloured with the same colouring matter as is present in the tube containing the blood, and is so calibrated that a reading of 100 per cent is equivalent to 17.2 grs. Hb. per 100 mls. of blood. In this method the Hb. is turned to a more stable acid haematin by means of N/10 hydrochloric acid.

The Sahli-Hayden haemometer is similar to the Sahli haemometer. Instead of having a standard fluid solution for colour comparison, a coloured glass comparator is used. This is fitted ^{over} one half of the three windows of the scale. Before actually carrying out a Hb. estimation, the magnifier is focussed so that the three windows are in sharp outline. Having placed the 20 cmm. of blood obtained by the standard pipette provided, in the graduated square glass tube, distilled water is added to the blood-hydrochloric acid dilution until the colour of the specimen, when viewed through the magnifier is nearest to a correct match with the central or standard coloured window. This type of apparatus has the added advantage over the Sahli haemometer, in that, the reading on the scale gives the Hb. estimation directly in grs. per 100 mls. of blood.

For

For the determinations of the erythrocyte counts the Thoma-Zeiss haemocytometer was used (43). The Thoma red cell diluting pipette is so graduated that dilutions of 1 in 100 or more of blood can be obtained. For the purpose of this work, a dilution of 1 in 200 was found to be sufficient. The writer used Hayem's diluting fluid for the erythrocyte counts, Sankaranarayanan (30) cites figures in comparison of three diluting fluids and although no appreciable difference was observed in the counts obtained, he states that citrate solution is preferable to either Toisson's or Hayem's because (a) it is easy to prepare, (b) it keeps a long time, (c) it gives a clear picture of the red cells and (d) filling and emptying the blood pipettes are easier using citrate solution. In this work by the present writer, Hayem's solution was found to give satisfactory results, no difficulty being experienced in carrying out the actual diluting technique.

The Thoma-Zeiss haemocytometer is equipped with the Levy counting chamber and the improved Neubauer ruling which facilitated the counting process. In this type of ruling the central square millimeter is divided into 400 small squares each of $1/400$ th sq. mm. in area. The counting chamber is $1/10$ th mm. deep giving each small square a cubic volume of $1/4000$ th cmm. In the actual determination of the number of erythrocytes contained in a sample of blood, the cells are counted in 5 groups of 16 smallest squares or in 80 of the 400 squares. The total red cell count may therefore be obtained by multiplying the number of cells counted by 10,000 or $(1/5 \times 1/10 \times 1/200)$. Therefore, in routine blood analysis, one adds to the cell count from 80 small squares, four cyphers.

6. Blood Preservation and Anticoagulants.

When it is impracticable to analyse blood samples immediately after drawing them, some means of storage and preservation must be pro-

vided

vided in order to obtain accurate results. In the first place one must prevent the coagulation of the cellular components of the blood. In this work, the writer used potassium oxalate to inhibit coagulation; .5 ccs. of a .2 per cent solution being used for 5 ccs. of whole blood. The use of anticoagulants offers many advantages, particularly when bleeding animals under field conditions. Stitt (43) recommends 2 mg. of potassium oxalate per cc. of blood as just sufficient to prevent coagulation.

Sankaranarayanan (30), working with Indian dairy animals, pointed out that the erythrocyte count was unaffected by ^{anti}coagulants, in his case sodium oxalate solution. He further states, however, that structural changes in the cells were noted: the red cells becoming crenated. Samples should be analysed within 24 hours after bleeding for, if the period be lengthened, inaccurate results are obtained (30, 18). However, from the results cited by Sankaranarayanan it may be concluded that fresh oxalated blood can safely be used for erythrocyte counts and Hb. estimations. Kerncamp (18) states that while it is possible to use blood oxalate mixture for making the various examinations included in a blood picture, the results are likely to give values that are significantly greater or less than the blood picture obtained from freshly drawn blood. He states, however, that the interval of time between drawing the blood and making the examination is more important, and as this increases there is a tendency for the Hb. values to increase and the number of red cells per cmm. of blood to increase. In this work, the writer, as far as was possible, analysed the samples immediately after drawing them. On occasions, when this was impracticable, the tubes, containing the blood oxalate mixtures, were kept in cold storage.

7. Results Obtained.

Blood samples of each animal were analysed at the beginning and at the end of the experimental period, which lasted for 10 weeks. In the case of the tick-infested animals, after being freed from ticks at the end of the 10 week period, a recovery experiment was conducted lasting a period of one month. At the end of this month the animals were bled again and the blood samples analysed. Results, following the above procedure, were recorded both in the wet and dry season trials. The results for Hb. were obtained in the wet season using the Sahli acid haematin method, and in the dry season using the Sahli-Hayden acid haematin method.

Tick-infested Group.

Table 10.

WET SEASON.

Name and No.	grs. Hb. per 100 mls. of Blood			Erythrocyte Count in Millions per cmm. of blood		
	Samples taken at start of experiment.	Samples taken at end of 10 week period	Samples taken at end of 4 week recovery period	Samples taken at start of experiment	Samples taken at end of 10 week period	Samples taken at end of 4 week recovery period
Crystalline 1.	8.2	7.1	7.7	4.81	4.08	4.5
Laurie II 2.	9.2	8.6	8.9	5.9	4.8	5.7
Isabella 3.	9.6	8.9	9.4	5.9	5.1	6.1
Soozee II 4.	9.5	9.3	9.4	6.2	6.1	6.1
Electra 5.	9.8	9.4	10.6	5.80	5.7	6.5
Amelia I 6.	10.0	9.6	9.9	5.8	5.5	5.8
Shiama III 7.	10.9	10.6	11.0	6.3	6.2	6.4
Jaiphallia III 8.	11.6	11.1	12.5	6.6	6.5	7.8
MEAN	9.85	9.32	9.92	5.9	5.5	6.1

Table 11.

Table 11.

Tick-free Group.

WET SEASON.

Name and No.	grs. Hb. per 100 mls. of blood		Erythrocyte Count in mil- lions per cmm. of blood	
	Samples taken at start of experiment	Samples taken at end of 10 week period	Samples taken at start of experiment	Samples ta- ken at end of 10 week period
Baby 1.	7.1	7.4	4.18	4.62
Belle IV 2.	9.9	10.3	5.8	5.5
Nymph III 3.	10.0	9.9	5.8	5.8
Mathilda 4.	10.1	10.3	5.9	6.4
Nancy Lovell II 5	10.3	10.8	6.1	6.3
Amelia II 6.	10.8	11.1	6.3	5.9
Ruby III 7.	11.0	11.6	6.5	6.5
Josephine III 8.	11.8	12.9	6.5	6.6
MEAN	10.1	10.5	5.9	5.95

GRAPH NO. 4.

Diagrammatic Representation of Hb. analysis of Cows
of Tick-Infested Group drawn to Scale 1" = 10 wks.

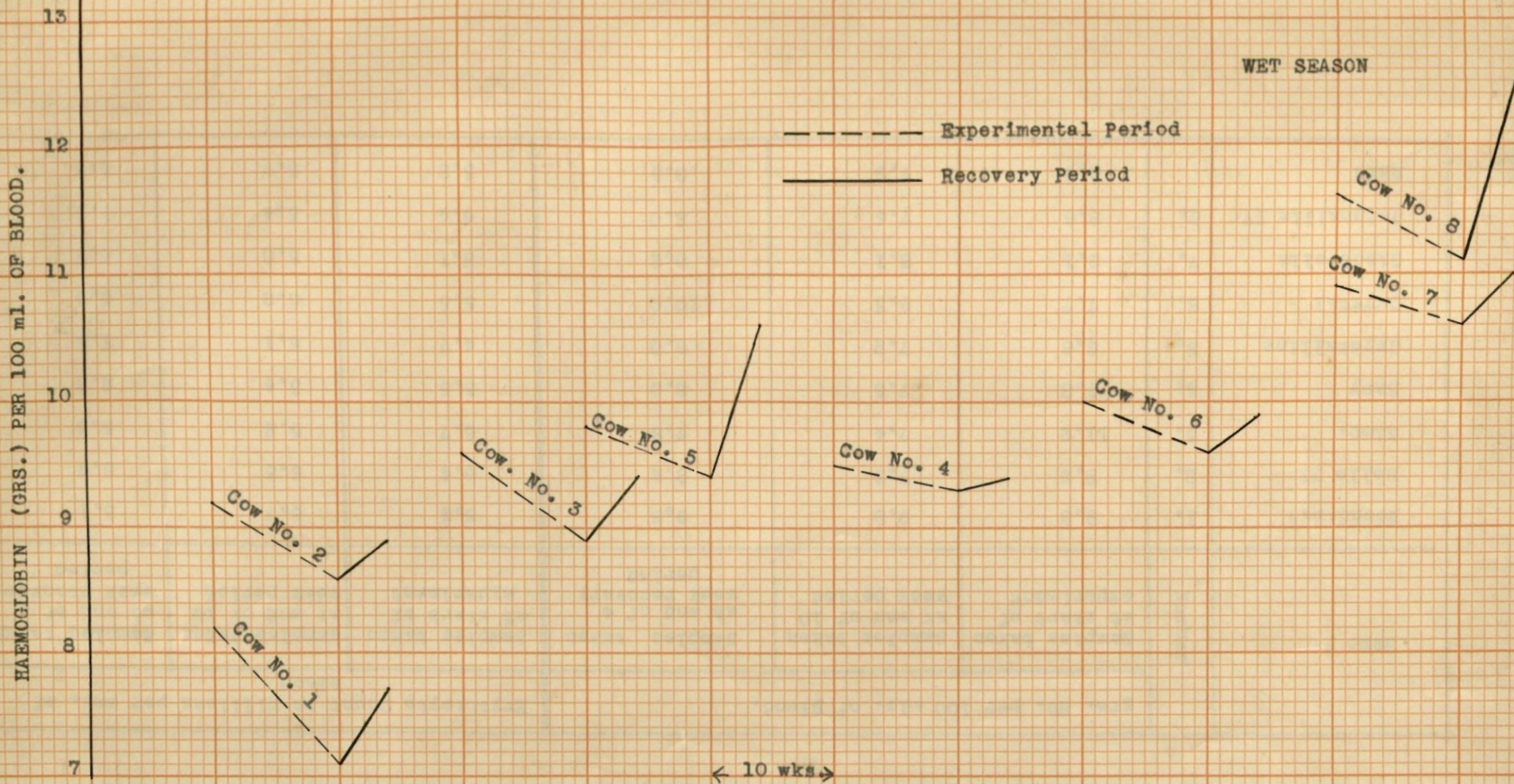


Table 12.

Tick-infested Group.DRY SEASON.

Name	Number	grs. Hb. per 100 mls. of Blood.			Erythrocyte Count in Millions per cmm. of blood		
		Samples taken at start of experiment	Samples taken at end of 10 week period	Samples taken at end of 4 week recovery period	Samples taken at start of experiment	Samples taken at end of 10 week period	Samples taken at end of 4 week recovery period
Moondaree	1.	9.8	9.8	9.8	6.4	6.7	5.1
Belle II	2.	8.2	7.3	8.2	5.4	5.3	5.9
Kimp.	3.	11.2	7.4	7.8	6.7	5.2	5.3
Baby	4.	7.8	7.6	8.0	5.5	5.4	5.4
Crystalline	5.	6.8	7.2	8.0	4.7	5.1	5.3
Crystal	6.	7.7	8.3	10.0	5.5	6.2	6.0
Cinderella	7.	8.1	8.1	8.2	6.1	5.8	5.8
Jaiphallia IV	8.	8.8	7.6	8.0	6.4	5.4	5.6
MEAN		8.6	7.9	8.5	5.8	5.7	5.6

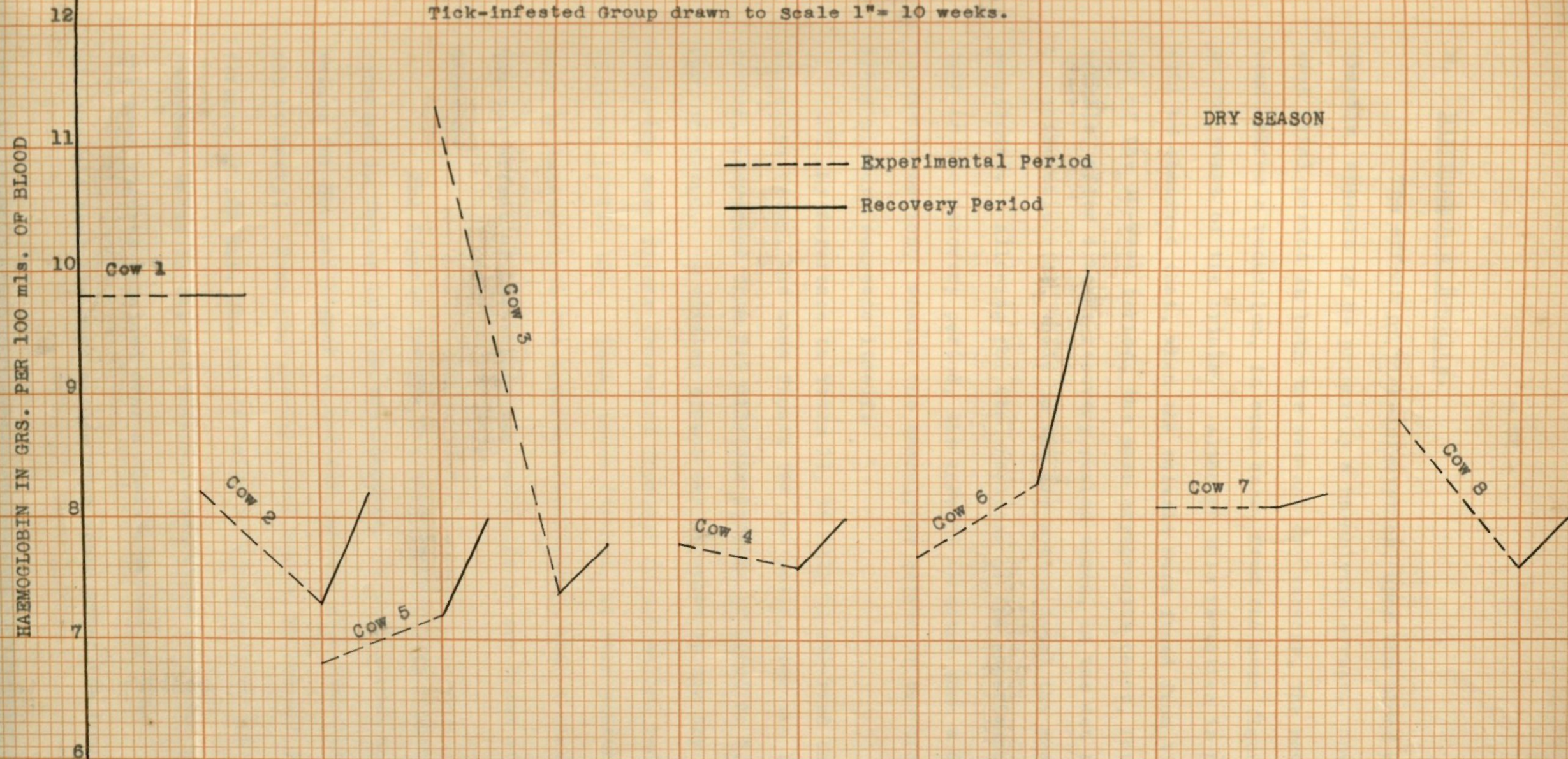
Table 13.

Tick-free Group.

DRY SEASON

Name	grs. Hb. per 100 mls. of Blood		Erythrocyte Count in millions per cmm. of Blood	
	Samples taken at start of experiment	Samples taken at end of 10 week period	Samples taken at start of experiment	Samples taken at end of 10 week period
Jaiphallia III	8.7	11.4	6.2	7.7
Laurie II	9.2	11.2	6.3	7.5
Isabella	8.0	8.5	5.3	6.4
Soozee II	8.3	8.0	5.9	5.8
Amelia II	10.0	12.0	6.5	6.8
Phoolwantia II	10.0	10.0	6.4	6.8
Gladys II	11.1	11.4	6.7	7.8
Shiama III	8.3	7.9	5.9	5.5
MEAN	9.2	10.1	6.2	6.8

Diagrammatic Representation of Hb. Analysis of Cows of
Tick-infested Group drawn to Scale 1" = 10 weeks.



8. Discussion of Results.

The effect of tick-infestation, upon the blood of parasitised animals, appears to be primarily a haemolytic effect. Over the 10 week trial period in both the wet and dry seasons, the mean erythrocyte count shows a reduction, in each case, from the mean figure recorded at the start of the trials. Although this reduction is not great, it will be observed that, when the animals were freed from ticks at the end of the 10-week period, the mean erythrocyte count, for the same animals, after 4 weeks recovery period shows, in the wet season trial, a considerable rise, while in the dry season trial the mean figure is maintained. Allowing for the shortness of the experimental period and that of the recovery period, the results recorded show a definite trend in the direction, whence the haemolytic effect of the tick, upon the blood picture suggests itself.

By reference to Table 11, it will be observed that with the tick-free group, the mean figure for red cells, over the 10 week trial period, increased from 5.9 millions per cmm. of blood to 5.95 mills. per cmm. of blood. A similar effect was recorded in the dry season trial where the mean figure increased from 6.2 to 6.8 mills. red cells per cmm. of blood (Table 13). Thus, those figures, in some measure, would appear to substantiate the apparent observation, that a tick infestation has the effect of destroying the red cells in the blood of parasitised animals.

The figures for Hb. are more interesting. When the results recorded in Tables 10 & 12 are compared, it is observed that the mean values for Hb. are higher in the wet season, when tick-infestation was not so heavy. Over the 10-week trial period in the wet season a difference of .53 grs. Hb. per 100 mls. of blood between the mean values is recorded, while in the dry season a difference of $.7 \frac{\text{grs.}}{\text{Hb.}}$ exists between the mean figures obtained over a similar period of time. It will also be observed that the mean values rise again after the four weeks recovery

ery period. In the wet season the mean value for the group increased from 9.3 to 9.9 grs. Hb. per 100 mls. of blood and in the dry season the mean value increased from 7.9 to 8.5 grs. Hb. In each case this represents an increase in the mean figure for the group, of .6 grs. Hb. per 100 mls. of blood.

On examination of the results recorded for each animal in the wet season trial it will be observed that, in every case, a decrease in the amount of Hb., over the 10-week experimental period, is recorded, and after the 4 weeks recovery period the Hb. index was observed to increase for each animal. This increase, as will be seen from Table 10, is by no means uniform. The highest increase recorded was that in the case of Cow No. 8, which showed an increase of 1.4 grs. Hb. per 100 mls. of blood over the 4 weeks recovery period. On the other hand, the lowest increase recorded was that in the case of Cow No. 4. In this instance, an increase, over the figure obtained at the end of the 10-week experimental period, of 0.1 grm. Hb. per 100 mls. of blood, being recorded. The respective Hb. indices, for each of the tick-infested animals are represented diagrammatically in Graph 4 when the effects can be more clearly observed.

In the dry season trial, the tick-infested cows, with the exception of two, showed a decrease in Hb. over the 10 week experimental period. From the results obtained, after the 4 weeks recovery period, all the animals again recorded an increase in their respective Hb. indices. The highest increase recorded was that in the case of Cow No. 6; an increase of 1.7 grs. Hb. being observed. Cow No. 1 was observed to maintain her original Hb. level throughout the 14 weeks of the experiment. Kimp, Cow No. 3, which became fairly heavily infested, shows a very acute decrease in Hb., a drop of 3.8 grs. per 100 mls. of blood being recorded in 10 weeks. Belle II and Baby, also fairly heavily infested, do not

show any acute decrease in Hb. Thus, it would appear that the nature and individuality of the animal, in addition to the effects produced by tick infestation, is concerned in the results recorded. Graph No. 5 shows the diagrammatic representation of the results. It is difficult to understand why Cows 5 & 6 showed an increase in their respective Hb. indices during the 10-week trial period. Both animals were moderately infested and it would appear that immunity and tolerance to the effects of tick infestations, were present in these animals to a greater degree than in the other animals, which were similarly parasitised. After being freed of ticks, however, the increase in Hb. in each case, over the 4 weeks recovery period, was fairly considerable and showed a relatively quicker rise than it did during the actual trial period.

The tick-free animals, during the wet season trial, showed that they not only maintained their Hb. level, over the 10 weeks, but actually increased it. The mean figure for the group was, at the start, 10.1 grs. Hb. per 100 mls. of blood and after 10 weeks free from tick infestation the mean figure recorded was 10.5 grs. Hb. per 100 mls. of blood. A similar effect was recorded during the dry season trial. From a mean figure of 9.2 grs. Hb. at the commencement of the work, the animals, by the end of the 10 week period recorded a mean figure of 10.1 grs. Hb., showing an increase in the mean figure of .9 grs. as against .4 grs. Hb. per 100 mls. of blood in the wet season.

9. Summary and Conclusions.

1. A study of the blood of 16 tick-free and 16 tick-infested dairy animals under Trinidad conditions is herein reported.
2. The observations and results cited were taken from experiments conducted in both the wet and dry seasons.

3. The

3. The mean Hb. values were higher in the wet season when tick infestation was not so heavy.
4. Over the 10-week trial period in the wet season, a difference of .53 grs. Hb. per 100 mls. of blood existed between the mean values, while in the dry season the difference recorded was .7 grs. Hb. per 100 mls. of blood over a similar period of time.
5. During the experiment in the wet season, all the tick-infested animals showed an increase in the Hb. index after a four weeks recovery period, during which they were free from the parasite. A similar effect was observed during the dry season, all the tick-infested animals showing an increase in the Hb. index after the recovery period.
6. This recorded increase was not uniform over the group but varied with each animal: a range of from 1.4 to 0.1 grs. Hb. per 100 mls. of blood being observed in the wet season and from 1.7 to 0 grs. Hb. per 100 mls. of blood in the dry season.
7. In the case of the tick-free animals, the results for Hb. showed that they not only maintained their initial level over the 10 weeks experimental period, but an increase in the amount of Hb. per 100 mls. of blood was actually observed, when the mean figures are compared in both the trials.
8. Over the 10-week trial period in both seasons, the mean erythrocyte count showed a reduction, in each case, from the mean figure recorded at the start of the trials.
9. The main conclusion that can be drawn from the results obtained herein, is that, the blood composition appears to be considerably affected by tick-infestation; these results indicating the haemolytic effect of the tick on the red blood cells and consequently upon the Hb. of the blood.

10. Recommendations.

1. In the event of such experiments, demonstrating the effects of the Cattle Tick - Boophilus annulatus Say - on the dairy cow, being repeated, it is suggested that the trials be conducted for a minimum period of 16 weeks. Over such a period of time, results should be of such a nature that definite conclusions could be made as to the magnitude of the effects, found to occur by the present writer.
2. That further experiments be carried out in an attempt to prove the apparent haemolytic effect of the tick on the red cells of the blood. It is suggested that urine analysis be carried out to detect the presence of excessive bile pigments.
3. Should the effect be proved to be haemolytic, investigations should be conducted to determine whether the tick itself is responsible or whether the haemolysis is due to an infectious agent e.g. protozoan or virus in nature, transmitted by the tick.

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13. Appendix I.

Observations Regarding the Tick Problem in Jamaica.

In April 1945, the writer visited Jamaica and was therefore able to obtain first hand information concerning this problem there. Since the livestock industry is of great importance in Jamaica, it is thought advisable to give a brief account of the tick problem and the measures in use for the control of this pest in that Island. From observations made on the many dairy and beef herds all over the island, it appeared to the writer that a good control of this parasite was being effected. The smaller farmers owning a hundred or less head of cattle employ a hand spraying machine to administer the dip - in their case usually Cooper's Cattle Dip. The larger farmers employ the dipping vat as the means of applying the remedy. It is pointed out (13) that where cattle are to be completely freed of ticks, the use of the dipping vat is the cheapest and best means of applying the dip. The liquid used in the dipping tanks is the Standard Departmental dip and it has been found to be highly efficient. It is essentially a Paranaph and Arsenic wash, the specific mixture being:- 2 lbs. arsenite of soda, 3 lbs. Paranaph and 100 galls. of water. The dipping process is carried out once every 14 days. Reinfestations of the parasite were, however, observed to be fairly rapid and a trace of nicotine was introduced into the dip. This mixture proved very effective as a control and consequently the tick population was considerably reduced.

Although sporadic cases of tick fever occur in the Island, great care is taken to infer an immunity to the effects of the tick in young calves, by allowing them to acquire a slight degree of tick infestation. On the whole, the problem in Jamaica appears to have been given a great deal

deal of attention and the writer was favourably impressed with the results obtained. The cattle, both dairy and beef breeds appeared in good bodily condition and did not seem to be upset by the few ticks they did harbour.

APPENDIX II

Table 14.

Daily Weights of All Animals in lbs. for Period 3rd to 9th July.

	July 3rd	July 4th	July 5th	July 6th	July 7th	July 8th	July 9th
Belle IV	966	962.5	962	934.5	938	973	973
Josephine III	878	870	904	868	889	868	882
Amelia II	913.5	906.5	931	764	966	945	924
Nymph III	871.5	878	850.5	857.5	865.5	826	850
Mathilda	798.0	840	843.5	812	847.0	812	822.5
Ruby III	700	700	703.5	686	728	707	696.5
Baby	770	752	784	749	766.5	766.5	777
Nancy Lovell II	763	777	794.5	763	801.5	766.5	805
<u>MEAN WEIGHT</u>	832.5	835.8	846.6	804.5	850.2	833.0	841.2
Electra	644	651	654.5	637	658	661.5	651
Laurie II	791	798	791	787.5	798	756	777
Shiama III	895	868	864.5	854	896	854	826
Soozee II	731.5	763	731.5	731.5	759.5	731.5	745.5
Jaiphallia III	1008	1029	1000	980	1022	994	976.5
Amelia I	903	924	896	910	913.5	882	882
Crystalline	813.5	806	812	770	805	784	808.5
Isabella	1011.5	997.5	987	973	1018.5	973	962.5
<u>MEAN WEIGHT</u>	849.7	854.5	842.0	834.8	858.8	829.5	828.6

Table 15

Daily Weights of All Animals in lbs. for Period July 28th to August 3rd.

	July 28th	July 29th	July 30th	July 31st	Aug. 1st	Aug. 2nd	Aug. 3rd
Belle IV	959	924	931	938	952	930	889
Josephine III	896	854	885.5	878.5	868	892.5	854
Amelia II	896	917	900	903	882	931	924
Nymph III	840	840	875	847	819	854	890
Mathilda	850.5	832	850.5	826	854	868	861
Ruby III	714	689.5	707	707	707	714	710.5
Baby	798	770	777	770	794.5	812	791
Nancy Lovell II	787.5	770	794.5	763	773.5	787.5	784
<u>MEAN WEIGHT</u>	842.6	824.5	840.0	829.1	831.2	848.6	837.9
Electra	658	659	672	665	672	672	693
Laurie II	756	777	777	784	780.5	777	826
Shiama III	840	847	833	826	826	875	882
Soozee II	756	735	728	749	756	749	791
Jaiphallia III	987	987	1001	1004.5	1008	1001	1022
Amelia I	906.5	875	896	878.5	896	889	924
Crystalline	784	780.5	798	798	794.5	812	805
Isabella	959	940	966	966	930	973	1001
<u>MEAN WEIGHT</u>	830.8	825.0	833.9	833.9	832.9	843.5	868

Table 16.

Daily Weights of All Animals in lbs. for Period Sept. 3rd to 9th.

	Sept. 3rd	Sept. 4th	Sept. 5th	Sept. 6th	Sept. 7th	Sept. 8th	Sept. 9th
Belle IV	997	1015	987	980	994	997	997
Josephine III	882	875	896	861	896	896	890
Amelia II	1008	980	987	962	903	914	920
Nymph III	882	868	896	850	861	865	873
Mathilda	882	868	882	857	896	896	872
Ruby III	717	721	742	728	742	744	744
Baby	819.5	914	840	819	847	851	866
Nancy Lovell II	773	805	882	784	798	798	802
<u>MEAN WEIGHT</u>	870.0	880.2	889.0	855.1	867.1	866.7	870.5
Electra	675.5	679	686	672	686	679	677
Laurie II	742	826	833	826	826	847	843
Shiama III	910	847	868	847	861	826	836
Soozee II	809	784	784	714	822	812	801
Jaiphallia III	1078	1036	1050	1060	1057	1036	1044
Amelia I	940	952	924	936	917	980	974
Crystalline	840	812	826	829	819	794	807
Isabella	987	980	1001	973	973	952	954
<u>MEAN WEIGHT</u>	872.7	864.5	871.5	857.1	870.1	865.7	867

Individual Records of Experimental Cows by 7-day Periods.Tick-free Group.WET SEASON

Cows	LBS. Milk Production for 7-day Period ending:-									
	8/7/44	15/7/44	22/7/44	29/7/44	5/8/44	12/8/44	19/8/44	26/8/44	2/9/44	9/9/44
Baby	111.5	121	138.5	151.0	158.25	145.25	157.75	144.75	150.5	168.25
Nancy Lovell II	96.5	101.25	87.0	80.0	85.75	69.5	62.25	48.5	43.0	32.75
Amelia II	69.25	50.5	54.5	43.75	42.5	35.0	30.0	17.5	8.75	4.0
Nymph III	127.25	117.75	90.0	106.75	121.75	108.5	112.5	106.0	101.25	100.5
Mathilda	89.25	82.5	88.75	85.25	91.0	82.25	78.25	74.25	65.25	68.0
Josephine III	107.75	107.25	92.0	90.75	89.75	103.75	93.25	88.25	79.25	85.5
Ruby III	103.75	101.75	94.5	92.0	91.5	81.75	83.75	80.75	80.5	78.5
Belle IV	89.25	93.25	97.25	85.0	84.0	84.0	89.0	73.0	69.25	74.75

Tick-infested Group:

Laurie II	110.5	103.5	110.25	116.0	105.25	97.0	85.5	82.25	75.0	75.5
Amelia I	111.25	108	105.5	110.0	95.0	92.0	94.0	94.25	87.75	89.25
Isabella	126.75	113	126.5	126.25	127.75	119.25	112.5	104.25	89.5	96.0
Soozee	74.75	68.0	67.0	51.5	43.0	41.5	29.25	25.0	18.5	5.5
Crystalline	87.75	101.75	94.25	96.25	96.5	99.25	90.0	87.75	74.5	82.25
Jaiphallia III	80.5	74.5	60.5	50.0	50.5	24.75	12.25	5.0	4.0	4.0
Shiama III	114.75	114.25	121.25	130.0	121.75	118.5	115.25	111.25	109.25	115.5
Electra Clarks	99.5	95.75	96.0	98.0	100.0	86.5	81.5	77.5	71.0	72.0

Table 18.

Individual Records of Experimental Cows by 7-day Periods.Tick-free Group.DRY SEASON

Cows	LBS. Milk Production for 7-day Period ending:-									
	24/2/45	3/3/45	10/3/45	17/3/45	24/3/45	31/3/45	7/4/45	14/4/45	21/4/45	28/4/45
Laurie II	109.5	106.0	110.0	108.25	117.0	106.75	95	98.25	98.75	89.75
Isabella	91.5	94.0	96.25	101.5	109.25	93.75	92.5	90.25	91.5	85.5
Soozee II	114.0	117.5	110.75	115.5	128.0	111.5	105.25	109.0	100.0	104.5
Amelia II	48.25	51.5	47.25	44.0	47.5	42.75	40.0	42.0	39.0	42.0
Phoolwantia II	147.5	143.25	148.5	144.75	149.75	138.0	130.25	127.75	117.0	121.5
Gladys II	111.5	114.0	111.5	113.75	127.5	105.5	100.25	105.5	97.5	99.0
Jaiphallia III	220.5	220.75	224.5	213.25	214.5	187.0	186.25	189.75	180.5	167.0
Shiama III	57.5	56.25	56.0	32.0	44.0	42.25	25.0	30.0	36.0	26.0

Tick-infested Group:

Jaiphallia IV	109.0	107.5	101.0	106.5	111.5	111.25	96.25	102.0	74.75	84.5
Cinderella	56.0	60.5	61.75	49.5	45.75	45.0	33.0	29.75	12.0	11.0
Crystal	166.75	149.0	139.25	158.5	166.75	157.5	138.75	154	132.0	131.5
Crystalline	45.5	47.0	36.0	14.0	13.0	13.0	12.0	12.0	11.0	10.0
Baby	125.75	123.25	126.5	132.75	137.5	140.5	111.0	106.75	101.5	99.0
Kimp	180.0	170.25	184.5	193.25	189.25	181.5	158.25	165.5	137.5	133.0
Belle II	105.0	105.5	98.5	105.75	116.5	107.5	88.5	89.25	88.0	87.0
Moondaree III	93.0	88.5	74.0	85.75	94.0	89.5	83.5	83.75	77.75	77.5