As regards the contradiction which Capt. Martin points out on page 209, I should have thought that what I wished to express would have been clear to the average intellect. The word "affected" is here used in a broader sense than to convey the meaning of "infected" only. In the second sentence I state the temporary infection and speak of the general health as not being affected.

SUGGESTIONS FOR A UNIFORM SYSTEM OF INTERPRETING THE TUBERCULIN REACTION IN CATTLE.¹

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By the tuberculin "reaction" is generally understood a rise in bodily temperature amounting to fever, which rise is accompanied by more or less acceleration of the pulse and breathing, less frequently by rigors, loss of appetite, and other visible signs of disturbance in the bodily functions. In adult cattle these secondary symptoms are less marked and are sometimes entirely absent. A "local reaction" (swelling) is not invariably to be expected, for experience shows that when it is possible to avoid irritating the skin at the point of inoculation (by clipping and shaving away the hair, washing with sublimate or strong alcohol) it fails to occur. As a consequence, the only reliable criterion of reaction is to be found in a distinct rise in bodily temperature amounting to fever.

What is to be Regarded as a Febrile Reaction in Cattle?

At the present moment we are not in possession of generally-recognised uniform data on which to base our answer to this question.

A priori we may assume one of two logical positions:—

(1) The decision may be based on the highest observed temperature after reaction, without reference to the animal's actual temperature before injection or to any arbitrarily fixed temperature.

In this case the highest temperature to be regarded as normal is fixed upon to begin with, and any rise beyond is regarded as a reaction.

(2) The decision may be based on the rise in temperature relatively to that observed before injection or to an arbitrarily fixed temperature.

In this case a certain rise in temperature is fixed upon as the utmost which can be regarded as falling within the normal limits of variation, and anything exceeding this, without reference to the absolute temperature attained, is regarded as a reaction. In this case different conclusions are possible, depending on whether we adopt as our basis the highest temperature recorded before injection, the average temperature of a series of readings, or the particular temperature existing at the moment of injection.

As a general rule, it is customary in medicine when using the first method to solve the question by comparing the highest observed temperature with a scale of normal temperatures compiled on the basis of prolonged observation for each species of animal. Having

¹ From the "Proceedings of the VIIIth International Veterinary Congress," Budapest.

regard, however, to the wide limits within which the ox's temperature may normally vary, it has always been a matter of great difficulty to fix a precise scale. The growing use of tuberculin in the early nineties rendered this question a very important one, and owing to its difficulty observers were more and more driven to base their conclusions on the relative rise in temperature, *i.e.*, to adopt method No. 2.

As a general rule the rise was measured as against the highest temperature recorded in a series of observations made before injection. The difference between the highest temperature before injection and the highest after was compared with a fixed standard of permissible variation, and the conclusion was arrived at in a purely mechanical way, *i.e.*, as to whether or not a given rise should or should not be held to constitute a reaction.

Most of the tests carried out for magisterial authorities during the early nineties were based on this method. The limits of "permissible variation" in bodily temperature were not then authoritatively fixed.

This method, however, is only free from objection when either a marked rise of temperature occurs or the rise is clearly of no importance. On the other hand, when the rise is of a moderate character only, the decision must largely be influenced by chance factors. And the fact that several measurements of temperature are necessary in order to fix a reliable medium temperature before injection is not precisely calculated to simplify the question.

The commencing struggle against tuberculosis about the middle of the last decade rendered it therefore increasingly necessary to discover the cause of the varying results given by tuberculin, and to provide fresh principles on which to interpret the temperature curves resulting from tuberculin injection.

The investigation was greatly facilitated by the fact that meanwhile the numerous tests made in large establishments had resulted in the collection of a great body of statistics, from which "normal limits" for the bodily temperature of cattle could be deduced, and the correct conclusions drawn from the highest observed reaction temperatures without reference to the pre-injection temperature.

It is therefore scarcely surprising that since the middle of the nineties most authorities have discarded the "relative rise" method, in favour of the "absolute rise," utilising for the purpose scales of temperature based on numerous and prolonged observations on cattle, and only falling back on the "relative rise" method in isolated special cases.

This method also seems to me best adapted at the present time as a basis for formulating a uniform system of interpreting the tuberculin reaction in cattle. Not the least recommendation is the fact that in this method the operator has need only to take the temperature *once* before injection, in order to ascertain if the animal is free from fever.

Reviewing the numerous publications on this head made since the middle nineties, it is satisfactory to find that most writers are unanimous in regard to many points in the interpretation of the temperature tables when using this method.

The following conclusions are strongly supported :—

(1) Any cattle, which at the moment of injection are free from fever (*i.e.*, whose temperature does not exceed 39.5° C.), and which

subsequently exhibit a rise above 40°C ., are to be regarded as having "reacted."

(2) In cattle up to six months of age, a rise not exceeding 40°C ., and in cattle of greater age a rise not exceeding 39.5°C ., is to be regarded as not warranting suspicion.

It would appear that essential differences of opinion would only occur in the case of rises of temperature between 39.5°C . and 40°C . in cattle older than six months.

Of such cases, however, most authors agree in regarding as reactions those in which the total rise above the pre-reaction temperature amounts to or exceeds 1°C .

The only doubtful cases, therefore, are animals over six months old in which the temperature rises to a point between 39.5°C . and 40°C ., and in which the difference between the highest temperature attained and the temperature before reaction is less than 1°C .

To dispose of these cases, however, without further test as "not warranting suspicion," as is recommended in the new Prussian regulations regarding the use of tuberculin, seems to be a mistaken policy, and I hold to the opinion that it is scientifically preferable to group them together as suspicions.

The number of these reactions will undoubtedly be affected by the manner in which the tuberculin test is carried out. My experience suggests that doubtful reactions will be rarer the sooner temperature measurements follow on the injection, the more frequent they are, and the longer they are persevered in. Nevertheless, they cannot be entirely avoided, especially when dealing with large groups of animals.

Experience shows that the "doubtful" group includes both tuberculous and non-tuberculous animals, and that the means at present at our disposal are insufficient to admit of precise distinction between them.

If the severity of the reaction were in direct proportion to the extent of the tuberculous changes, it would be easier to contemplate the results of any errors arising from faulty diagnosis (such, for example, as the strict application of the above-mentioned Prussian order would have), for at the worst only a slightly tuberculous animal would be passed as healthy. But experience shows that the animal which reacts but slightly is often found on *post-mortem* examination to have extensive tuberculous lesions. It is very clear, then, that to entirely pass over or to wrongly interpret the reactions lying between 39.5°C . and 40°C . may be fraught with serious consequences.

In the numerous tuberculin tests I have carried out, I have always regarded those animals of the so-called "doubtful reaction" group whose highest temperature reading exceeded the primary temperature by at least $.5^{\circ}\text{C}$., and whose temperature curve showed the unmistakable characteristics of fever (gradual rise, pause at the summit, and gradual decline), as having reacted. Those animals of the doubtful group, however, whose highest temperature reading fell short of a total rise of $.5^{\circ}\text{C}$., or whose reading, whilst exceeding $.5^{\circ}\text{C}$., showed only isolated, uncoordinated rises, I regarded as not reacting. At the same time—and I lay special emphasis on this—the condition of the animals was also tested by a thorough clinical examination.

Whoever practices this method of diagnosis, utilising every means of control that offers, and checking his results by *post-mortem* examination, will soon attain such skill in judging of the so-called doubtful reactions as to be able to distinguish with a very fair degree of certainty between the tuberculous and the healthy.

In those countries in which an attempt has been made to combat tuberculosis by the use of tuberculin it is easy to adopt the method, practised in Denmark, of leaving the final decision of doubtful cases to the same central organisation as is entrusted with the business of stamping out the disease. This method has the further advantage that the experience acquired can thus be best utilised for the general good.

I am therefore of opinion that the so-called doubtful reactions are not beyond the scope of scientific exact investigations, and that the decision as to which animals are suspicious and which non-suspicious is not to be settled by schematic formulæ, but by the application of the experience acquired by study of individual cases.

Nevertheless, circumstances exist under which it is desirable to have available a simple formula which will allow us promptly, without difficulty and with a fair degree of certainty, to discriminate between suspicious and non-suspicious cases. Ostertag's proposed rule conforms to these requirements, viz., that any animal over six months of age whose temperature rises above 39.5° C. and exceeds by $.5^{\circ}$ C. the highest temperature shown before injection should be regarded as having reacted.

Kühnaus goes a step further, and views any rise of temperature above 39.5° C. in adult cattle as a reaction.

Both propositions have in practice the great advantage of providing a simple easily-understood method of distinguishing between reacting (suspicious) and non-reacting animals whilst avoiding the bugbear of doubtful reactions. Nevertheless there is no doubt that this facility of diagnosis is only attained at the cost of reliability, and that every now and then an entirely healthy animal will be condemned as tuberculous. The possibility of such an occurrence must naturally be somewhat greater when using Kühnaus' than when using Ostertag's formula, for which reason it would be well to insist on a minimum rise of $.5^{\circ}$ C. However this may be, mistakes resulting from the use of these simplified rules of diagnosis are less serious as regards the stamping out of tuberculosis than errors in the opposite direction, leading to the introduction of tuberculous animals into healthy herds. It depends very largely, therefore, on what object one has in view in applying the tuberculin test whether one should employ the simplified formulæ of Ostertag and Kühnaus, or institute an investigation on the basis of the above described principles. In my opinion, however, an investigation of the above kind can scarcely be omitted when the tuberculin test is invoked to determine whether or not a given animal should be slaughtered.

As cattle less than six months old seldom suffer from extensive tuberculous changes, it is necessary, in their case, to deal with doubtful reactions in a special way.

According to Ostertag, all rises in temperature above 40° C. in animals less than six months old may at once be set down as reactions, provided the highest temperature after injection exceeds the highest

temperature before injection by at least 5° C. As long as one observes the precaution not to submit to the tuberculin test any animal of this age, whose temperature exceeds 39.5° , there only remains the measurement of the relative rises in temperature. Nevertheless, the strict observance of this rule in young cattle, whose temperature is known by experience to be higher than that of older animals, may occasionally give rise to difficulties.

On the basis of the foregoing propositions I make the following suggestions for the formulation of uniform principles for interpreting tuberculin reactions in cattle.

(a) For young cattle up to the age of six months:—

In young cattle, up to the age of six months, whose temperature previous to tuberculin injection does not exceed 40° C., any rise above 40° C. is to be regarded as a reaction, provided the difference between the highest temperature before injection and the highest after amounts to at least 5° C.

(b) For cattle above six months of age:—

(1) No animal whose temperature exceeds 39.5° C. to be tested..

(2) Rises of temperature to 39.5° C. after injection to be regarded as non-suspicious.

(3) Every animal whose initial temperature is below 39.5° C., and which shows a rise above 40° C., to be regarded as suspicious.

(4) Rises in temperature between 39.5° C. and 40° C. to be accounted reactions, provided the difference between the highest pre-injection and the highest post-injection temperature amounts to at least 1° C.

(5) Rises in temperature between 39.5° and 40° C. to be considered as doubtful in cases where the difference between the highest pre-injection and the highest post-injection temperature is less than 1° C. Such cases to be separately considered.

The separation of these cases into reacting and non-reacting to be otherwise determined. In this connection valuable indications are to be found in a comparison between the highest pre-injection and post-injection temperatures, which as a rule in reacting animals should amount to at least 5° C.; in the character of the temperature curve, which in reacting animals should display the regular fever form; and in the results of a careful clinical examination, which should be instituted in all doubtful cases.

(6) In all cases met with in current practice, where the tuberculin test is only invoked in order to ascertain the extent of tuberculosis in a herd or to separate tuberculous from non-tuberculous animals for the purpose of fighting tuberculosis, it is sufficient to accept Ostertag's formula, and regard all cattle as suspicious in which an injection of tuberculin causes the temperature to rise above 39.5° C., and in which the highest post-injection temperature exceeds the highest pre-injection temperature by at least 5° C.