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Trace element deficiencies—a new approach to diagnosis

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ABSTRACT

Results from vitamin B_{12} response trials are used to illustrate a methodology which it is claimed will provide a more useful interpretation of animal tissue analyses for the diagnosis of trace element deficiencies. Traditional reference ranges which divide tissue levels into the categories of *responsive*, *marginal*, and *adequate* are replaced by reference curves which, for a given tissue level, provide the *expected response* and the *probability of an 'economic' response*. The approach should provide farmers and veterinarians with better information to decide on remedial action. The prospects look promising for the production of reference curves for cobalt and selenium, and hopeful for copper. It is suggested that the methodology could be applied in other biological systems involving deficiencies, in particular, to the diagnosis of phosphorus and other deficiencies in plants.

Keywords Trace element deficiencies; diagnosis; methodology

INTRODUCTION

Short of carrying out a dose-response field trial (with its consequent demand on expertise and resources, and delay in getting results) the laboratory analysis of animal tissues has been considered the most effective way of diagnosing the trace element status of a group of animals (Towers and Clark, 1983). MAF Animal Health Laboratories in New Zealand process about 58 000 tests per annum for trace element status. Any improvements in the interpretation of these laboratory results would clearly have widespread value. The paper aims at providing a more useful interpretation than has been available in the past.

The complete range of possible laboratory test values has been traditionally divided into 3 zones—a 'responsive', an 'adequate', and an intermediate 'marginal' zone (Animal Health Division, MAF, 1982). Such reference ranges assist in determining whether a deficiency exists and whether remedial action is necessary (Fig. 1).

In the past, production reference ranges appear to have been determined by a somewhat loose association of tissue levels with the occurrence or absence of production responses to supplementation.

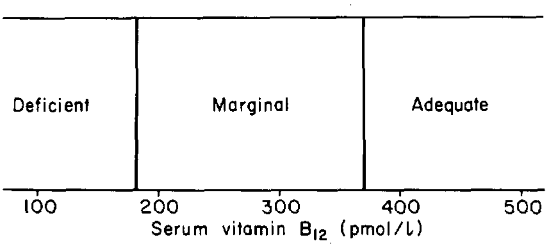

FIG. 1 Reference ranges.

The location of a laboratory test value in the marginal zone does little to assist in the decision-making. An improved way is needed of interpreting laboratory results in terms more useful to veterinarians and farmers. This is proposed by the development of 'reference curves' (Fig. 2). For a given tissue level, the *expected response* to treatment and the *probability of an economic response* can be read off these curves. The methodology is illustrated using a series of vitamin B_{12} live-weight response trials with lambs (Animal Health Division Project 299).

METHOD

Each datum point in Fig. 2 represents a trial in the series. The y co-ordinate gives the mean live-weight response of B_{12} treated lambs (20 per group) over the 2-month period December-February, standardised to g/d. The x co-ordinate gives the mean vitamin B_{12} level of serum from 10 untreated lambs sampled near the midpoint of the response period.

A response curve, in this instance an exponential curve of the form $y = a\ (1 - e^{-b(x-c)})$, was fitted by least squares to the data points. The solid line thus derived in Fig. 2 is called the 'expected response curve'. Because responses are more variable at low levels of serum vitamin B_{12} than at high levels, weighting was tried to give more weight to the less variable data. As it had little effect on the reference curves unweighted curves were used.

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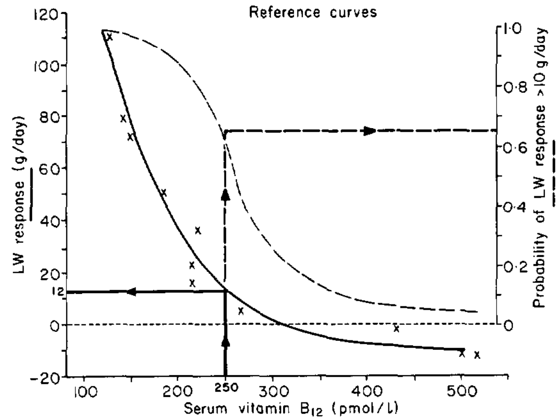

FIG. 2 Reference curves.

A live-weight response of 10 g/d was used as an approximate economic break-even point. Based on the method of Kendall and Stuart (1977) for determining the approximate variance of a nonlinear fitted curve, the probability of getting a response of at least 10 g/d was calculated and plotted as the 'Probability of an Economic Response' in Fig. 2 (broken line). Other such curves representing the probability of response above a different level (or family of such curves) can be plotted.

INTERPRETATION

To illustrate the interpretation of Fig. 2, consider a flock with a mean vitamin B_{12} level of 250 pmol/ℓ. This would indicate that a response of 12 g/d to cobalt supplementation could be expected. The estimated probability of an economic response (taken as ≥ 10 g/d) is 0.65. (The probability of response above a different level to 10 g/d could be provided by another curve). The farmer, in consultation with his veterinarian, could then make a more considered judgement (compared with that previously available) on whether to treat or not. This decision should be based on economic grounds and consideration of factors related to the epidemiology of cobalt deficiency (e.g., time of year).

DISCUSSION

Initially it is intended to produce reference curves using data from all appropriate New Zealand trials. Provided the relationship between tissue level and production response is good, such curves should be useful. Poorer relationships will lead to flatter 'Probability of Response' curves and reduced powers of discrimination between deficiency and sufficiency situations. If extraneous factors (such as nutritional level, season and breed) are found to influence the reference curves, separate ones can be drawn for combinations of such factors. As more data become available, they can be updated and the influence of extraneous factors studied in greater depth. Useful reference curves will reduce the need for field trials which, if carried out thoroughly, require time, expertise and resources.

Reference curves can be produced for cobalt, selenium and possibly copper deficiencies in sheep and cattle. Because of the likely strengths of the relationships, the prospects of developing useful reference curves appear excellent for cobalt (especially in sheep), good for selenium, and hopeful for copper.

CONCLUSION

The approach has the following benefits over the traditional method:

- It amalgamates all relevant trial data into a single interpretive procedure.
- It provides a more useful interpretation of tissue level analysis in terms of the expected response and the probability of getting an economic return from treatment.
- It will enable the identification of factors influencing production response. This should help in tightening up on some response/tissue level relationships (even for copper perhaps) and assist with the development of a standard trial protocol so that appropriate supplementary measurements can be taken.
- It provides a means of determining the best tissue analysis (to use on the x axis in Fig. 2).
- It indicates the range of tissue levels of animals that should be used in future trial work.

As well as its value in animal health, the reference curve methodology could be applied in other biological systems involving deficiencies such as nutrient deficiencies in plants. Like their counterparts investigating animal deficiencies, researchers of plant nutrient deficiencies have preferred to consider 3 zones—a deficiency zone, a critical nutrient range (analogous to the marginal range) and an adequacy zone (Dow and Roberts, 1982). Since the decision required is a simple one—whether to take remedial action or not—we claim that knowledge of an expected response and an estimated probability of 'economic' response is more appropriate than a method involving a marginal zone (often wide) of uncertainty.

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