

Students of these figures must be reminded that bush-sick soils are well-leached soils and likely to be deficient in many elements which have no significance in nutrition compared with soils on country derived from the parent rock containing a superabundance of unessential elements. The great American authority C. A. Elvehjem, in "Trace Elements in Hemoglobin Building," quotes with evident approval the following on the subject of cobalt with relation to the blood:—

"Fischer and Scott (Biochem. J., 19, 1055, 1935) have recently reported the non-presence of cobalt in the pancreas of cattle of any age. They place cobalt in the realm of pharmacology and toxicology rather than nutrition; however, an understanding of the mechanism by which cobalt produces polycythemia may be helpful in furthering our knowledge of hemoglobin formation."

*Pasture Samples.*—Cocksfoot-grass from Kaharoa (bush-sick area) was found to contain 38 p.p.m. of zinc, while a sample of cocksfoot-grass from Northland, Wellington, contained 32 p.p.m.

Cobalt could not be detected in several samples of pasture examined from both sick and healthy areas. It would therefore appear that cobalt is not taken up from the soil by pasture in appreciable amounts and that the good results in preventing bush sickness which are obtained by top-dressing pasture with ferrous sulphate are probably due to increased absorption of iron from the soil by the pasture which might present it in a condition peculiarly suitable for assimilation by the ruminant.

*Animal Specimens.*—No cobalt was found in the pancreas of a healthy bullock. Traces were found in the testes of healthy rams and bulls (less than 0.2 p.p.m. dry weight). The livers of bush-sick sheep showed faint traces of cobalt (about 0.06 p.p.m.), compared with the value of 0.20 p.p.m. in a healthy sheep. Less than 0.06 p.p.m. was found in the brain of a healthy sheep.

The zinc content of testes of healthy sheep from bush-sick areas ranged from nil to 43.9 p.p.m. of dry tissue, compared with 64.0 to 80.8 p.p.m. for sheep from healthy areas.

A liver of a sick sheep from the bush-sick area contained 140.8 p.p.m. zinc in dry tissue, compared with 254.6 p.p.m. in the liver of a Wellington (healthy) sheep.

*Ionizable Iron.*—The available or ionizable iron in bush-sick and healthy pastures and root crops is being estimated by the dipyrldyl method. Eleven parts per million dry weight were found in cocksfoot-grass from Kaharoa (sick) and 7 p.p.m. to 11 p.p.m. in cocksfoot-grass from Wellington.

Ionizable or soluble inorganic iron is now recognized to be the form in which iron is assimilated by the animal. Organically combined iron is much less readily or not assimilated. Part of the total iron content of most vegetable and animal tissues exists in each condition.

*Total Iron.*—A liver from a bush-sick sheep contained 151.8 p.p.m. iron in dry tissue, as compared with 234.1 p.p.m. in a Wellington (healthy) liver. In this case, therefore, there was no evidence of storage of excess of iron in the liver due to non-utilization, as is stated to be the case in enzootic marasmus.

*Vanadium.*—Vanadium was specially sought for in the acid extracts of limonite with negative results. Methods for the estimation of cobalt and zinc in minute amounts have been investigated. It was found that the most suitable reagent for the micro-estimation of cobalt was nitroso R-salt. A standard procedure involving separation of iron, and avoidance of strong oxidizing and reducing agents in the final test solution was evolved whereby estimations down to 0.001 mg. cobalt could be carried out. After trials of other methods, the oxalate-ferrocyanide turbidity method of P. L. Hibbard for the determination of zinc was adopted.

*Blood Analyses and Field Experiments.*—The field-work in connection with these investigations designed in this laboratory was all carried out by Mr. C. R. Taylor.

Blood-samples numbering 396 have been obtained from Atiamuri and Kaharoa, with a few from Mamaku and Morton Mains. An investigation was commenced at Kaharoa in February and completed in November. Seven sheep were fed as follows: No. 1, Australian limonite; No. 2, specially purified iron and ammonium citrate; No. 3, Reyburn's limonite; No. 4, Kenya iron oxide; No. 5, Lux (a residual iron oxide left after extraction of alumina from bauxite by alkali); Nos. 6 and 7, copper sulphate. The sheep had been on bush-sick country for some time and were low in condition, probably on account of incipient bush sickness. All the sheep were grazing on a pasture that had been heavily top-dressed over a number of years with superphosphate, basic slag, and other manures. This paddock was regarded as less bush-sick than others on the farm, but was handy for attending to the drenching of the animals. Blood-samples were taken once a fortnight, these being analysed for total solids, total iron, non-haemoglobin iron and copper. The variations for total iron and total solids of each sheep are similar, showing a definite relationship. These values also increased as the health of the sheep improved. The non-haemoglobin iron was a small fraction of the total iron and seemed to have no significant connection with the health of the animal. The values for total solids varied from 12 gm. to 22 gm. per 100 cc., for total iron from 20 mg. to 48 mg. per 100 c.c. The total iron on normal healthy blood gave an average value of 49.4 mg. per 100 c.c.

The copper content of the blood of sick sheep in the Rotorua District was 0.093 mg. to 0.16 mg. per 100 c.c., which is lower than Tompsett's value for healthy sheep (0.161 mg. to 0.183 mg. per 100 c.c.), but since the figures for healthy sheep in this district vary from 0.083 mg. to 0.160 mg. the copper figures have no clinical value. The sheep fed on copper sulphate gave an average value of 0.148, but they went back in condition. (It is interesting to note that the copper value from Morton Mains samples is very high; healthy sheep 0.165 mg. to 0.230 mg., and sick sheep 0.215 mg. to 0.217 mg. per 100 c.c.) The sheep fed on copper sulphate were changed to cobalt chloride. One died almost immediately, but the other was making good progress.

No. 3 on Reyburn's limonite completely recovered in three months. The total solids of the blood were 20.1 gm. per 100 c.c. and the total iron 48 mg. per 100 c.c. Those fed on Australian limonite, specially purified citrate, Kenya iron oxide, and Lux all improved slowly until they had lambs, and then they went back a little in condition. The total solids of the blood rose from an average of 15 gm. to 19 gm. per 100 c.c., and the total iron from 25 mg. to 35 mg. per 100 c.c.