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SEASONAL FLUCTUATIONS OF HEPATIC VITAMIN A RESERVES IN BEEF CATTLE GRAZING UNIMPROVED PASTURES

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SUMMARY

The hepatic reserves of vitamin A were determined in three groups of beef cows and calves grazing pastures throughout two consecutive years.

Group differences in the hepatic reserves of vitamin A in calves were probably an effect of age.

In the first year the mean liver concentration (μg/g) of 18 cows and 30 calves was 232 $\pm$ S.E. 11 and 96 $\pm$ 3 respectively. In the second year the respective levels for 26 cows and 26 calves were 281 $\pm$ 11 and 86 $\pm$ 3. Levels were lower in summer compared with winter.

There was a high degree of repeatability in the level of vitamin A for each animal.

All the cows had adequate reserves of vitamin A. It is suggested that sub-optimum levels found in five young calves were due to an inherent reduced ability for vitamin A storage which had no effect on their performance.

I. INTRODUCTION

Although vitamin A supplementation of grazing beef cattle is practised to some extent in Queensland, the only documented data from Australia on hepatic reserves of vitamin A in cattle have been obtained before and after simulated drought feeding experiments (Ryley, Gartner, and Morris 1960; Ryley and Gartner 1962), before and after intensive finishing of steers on high-grain rations (Morris 1966; Morris and Gartner 1966, 1967; Gartner, Morris, and Clark 1967) and in drought-affected cattle (Gartner and Alexander 1966).

The object of the investigation reported in the present paper was to define the hepatic reserves of vitamin A in beef cows and calves grazing unimproved pastures in a subtropical environment. The effects of years and seasons, the variation between groups of animals and the repeatability of the liver vitamin A determination were examined.

II. MATERIALS AND METHODS

Description of property.—The investigation was done at "Brian Pastures" Pasture Research Station which is situated about 10 miles from Gayndah in south-eastern Queensland in latitude 25°S. The property consists of ridges of varying slopes and broken areas of river bank and flood plain regions along the small creeks flowing into Barambah Creek, which forms the eastern boundary of the property. The vegetation was originally an open eucalypt forest and the pasture grasses are now mainly bunch spear grass (*Heteropogon contortus*) and a number of blue grasses (species of *Dichanthium* and *Bothriochloa*). These are essentially summer-growing species and are virtually non-productive during the winter months. The average rainfall of the district is about 29 in. and is mainly of summer incidence.

Animals.—The animals sampled were born and reared at "Brian Pastures" and formed part of breeding herds in a time-of-calving experiment, the design of which was described by Sutherland (1961). Hereford and Poll Hereford cows were mated to Poll Hereford bulls at the following periods:—

Group 1 were mated from October 8 to December 7

Group 2 were mated from January 8 to March 9

Group 3 were mated from April 8 to June 7

All the cows sampled in 1964-65 were from 8 to 9 years of age. In 1965-66, the cows from groups 1 and 2 were from 9 to 10 years of age whereas those from group 3 were either 6 or 9 years of age. The calves selected for the investigation were male and female progeny of cows from the three mating groups. Although their ages ranged from 3 to 22 months, they will all be referred to as calves in this paper.

Liver vitamin A analyses.—Liver samples obtained by the aspiration biopsy technique of Loosmore and Allcroft (1951), using the instruments described by Dick (1952), were analysed for vitamin A by the method described by Morris and Gartner (1966). The samples were stored for 24–72 hr prior to analysis.

Design.—The investigation was divided into two separate 12-month periods: from May 1964 to May 1965 and from May 1965 to May 1966. Liver samples were taken by biopsy in May, August, November, February and May from the groups of animals described in Table 1.

TABLE 1

DESCRIPTION OF CATTLE USED IN THE INVESTIGATION OF HEPATIC VITAMIN A RESERVES

Attribute	Group 1	Group 2	Group 3
Cows:			
No. sampled 1964–65	6	6	6
No. sampled 1965–66*	10† (3)	10‡ (5)	6 (0)
Mean calving date 1964–65	Aug. 10	Nov. 9	Jan. 25
Mean calving date 1965–66	July 30	Nov. 25	Jan. 23
Mean calving date 1966	Aug. 2	Nov. 2	Dec. 10
Stage of lactation in May	Dry	End of lactation	Lactating
Stage of lactation in August	Just calved	Dry	End of lactation
Stage of lactation in November	Lactating	Dry—prior to calving	Dry
Stage of lactation in February	End of lactation	Lactating	Just calved
Calves:			
No. sampled 1964–65	10	10	10
No. sampled 1965–66	10†	10	6
No. sampled 1966§	9	6	5
Mean age in May (months)	9·0	5·6	3·2
Mean age in August (months)	12·7	9·2	6·9
Mean age in November (months) ..	15·3	11·8	9·5
Mean age in February (months)	18·5	15·0	12·7
Mean age in May (months)	21·3	17·8	15·5

* Figures in parenthesis show the number of cows that were carried on from the previous 12-month period.

† Reduced to 9 cows and calves after first sampling.

‡ Reduced to 7 cows after first sampling.

§ Sampled once only, age being 7 months, 6 months and 5 months for groups 1, 2 and 3 respectively.

Six cows with calves at foot were selected at random in 1964 to form each of the groups. Four additional calves were sampled from each mating group. As far as possible, cows previously biopsied were maintained in the following year if they had a second calf and cows with calves at foot were added to make up the required numbers of cows. A third drop of calves—that is, those born to the 1965-66 cows during the second 12-month sampling—were analysed to augment data on liver vitamin A reserves of calves at approximately weaning age.

The animals grazed throughout the year and were not fed supplements at any stage. Calves were weaned at approximately 6 months of age. All animals were brought from the grazing paddocks to yards on the day preceding biopsy and samples were taken the next morning. Unfasted body-weights were obtained every 4 weeks.

III. RESULTS

The cows and calves are best defined by considering their body-weight changes given in Figure 1. As body-weight changes in relation to time were comparable in all mating groups, a mean body-weight value is given for all the cows and for all the calves. The total monthly rainfall and the mean monthly maximum and minimum temperatures are presented also in Figure 1 in order to define some of the environmental conditions.

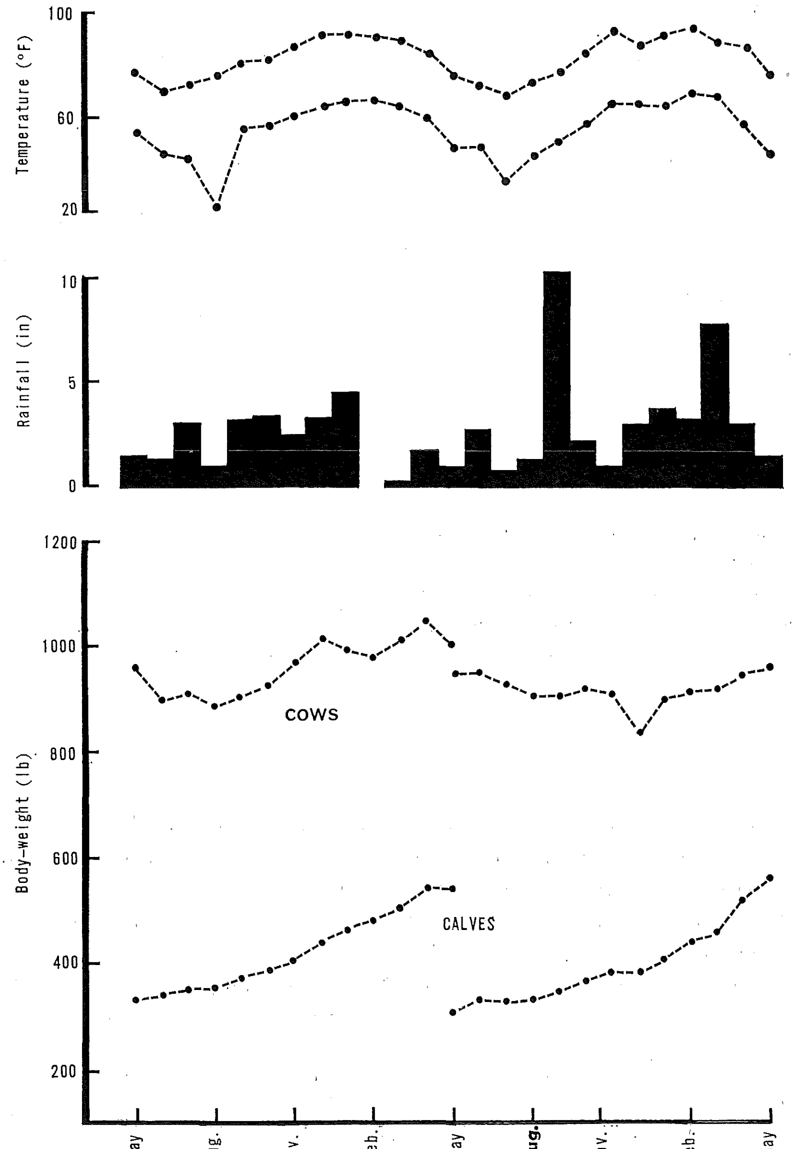

Fig. 1.—Mean body-weights of beef cattle grazing unimproved pasture together with climatological data defining the conditions during the survey.

The mean weight of the 485 liver samples obtained by biopsy was 0·6626 g ± S.D. 0·0135.

TABLE 2

Group Means, Standard Errors of Means and Significant Differences for Hepatic Vitamin A Reserves in Cows and Calves Grazing Mainly Bunch Spear Grass (Heteropogon contortus)

Attribute	Hepatic Vitamin A Reserves (μg/g ± S.E.)		
	1964–65	1965–66	1964–66
Cows:			
All groups	232 ± 11	281 ± 11	
Necessary differences for significance	29 (5%) 39 (1%)		
Group 1	253 ± 18	257 ± 18	255 ± 13
Group 2	197 ± 18	251 ± 18	224 ± 13
Group 3	246 ± 18	333 ± 18	290 ± 13
Necessary differences for significance	N.S.	N.S.	36 (5%) 48 (1%)
May	201 ± 21	265 ± 21	233 ± 15
August	302 ± 21	299 ± 21	301 ± 15
November	229 ± 21	297 ± 21	263 ± 15
February	196 ± 21	262 ± 21	229 ± 15
Necessary differences for significance	N.S.	N.S.	42 (5%) 55 (1%)
Calves:			
All groups	96 ± 3	86 ± 3	
Necessary differences for significance	8 (5%) 10 (1%)		
Group 1	114 ± 5	110 ± 5	112 ± 3
Group 2	97 ± 5	69 ± 5	83 ± 3
Group 3	77 ± 5	79 ± 5	78 ± 3
Necessary differences for significance	14 (5%) 18 (1%)	14 (5%) 18 (1%)	10 (5%) 13 (1%)
May	43 ± 6	58 ± 6	50 ± 4
August	146 ± 6	100 ± 6	123 ± 4
November	126 ± 6	102 ± 6	114 ± 4
February	71 ± 6	85 ± 6	78 ± 4
Necessary differences for significance	16 (5%) 21 (1%)	16 (5%) 21 (1%)	11 (5%) 15 (1%)

The mean hepatic vitamin A concentrations of the animals are given in Table 2. Significant differences of these concentrations were obtained for both cows and calves between years, between groups and between sampling periods. Taken over both years, the mean level in the cows was highest in August and lowest in February and May, these differences being highly significant ($P < 0 \cdot 01$). Levels in the calves were highest also in August and significantly lower in February ($P < 0 \cdot 01$) compared with November and August. The calves from group 1 had the highest reserves, but this was not related to higher reserves of their dams as compared with dams from the other two groups.

Levels indicating vitamin A deficiency were not encountered in the cows and individual values ranged from 31 to 512 μg/g. Five calves with ages ranging from 3 to 7 months had levels less than 10 μg/g. There were 2 calves from group 3 which had levels of 3 and 6 μg/g in May 1964, and 3 calves, one each from groups 1, 2 and 3, which had levels of 1, 5 and 4 μg/g respectively at weaning in 1966.

TABLE 3

Interactions of Sampling Period, Groups and Years for Hepatic Vitamin A Reserves in Calves

Sampling Period	Hepatic Vitamin A Reserves in Calves (μg/g) from					
	Group 1		Group 2		Group 3	
	1964–65	1965–66	1964–65	1965–66	1964–65	1965–66
May	74	89	31	53	24	33
August	177	125	157	71	104	104
November	130	129	125	78	122	98
February	77	99	78	75	60	81

S.E. ± 9·7 Necessary differences for significance = 27 (5%); 36 (1%)

The second- and third-order interactions involving sampling periods, groups of cows and years were not significant. However, those of the calves were significant for each of the two years of the investigation (Table 3). These results are confounded by the variation in age between the groups at any sampling period. Despite this age effect, the lowest values were found in May in all groups and the highest values in either August or November.

TABLE 4

Repeatability of Hepatic Vitamin A Reserves in Cattle

Groups	Repeatability		
	1964–65	1965–66	1964–66*
Cows:			
Group 1	0·36†	0·81‡	0·42‡
Group 2	0·31†	0·84‡	0·65‡
Group 3	0·79‡	0·29†	—
Calves:			
Group 1	0·47‡	0·61‡	—
Group 2	0·48‡	0·79‡	—
Group 3	0·44‡	0·35†	—

* Repeatability could only be estimated where cows were common to both years.
† Significant at the 5% level.
‡ Significant at the 0·1% level.

Estimates of repeatability were made on the hepatic vitamin A levels in cattle from the various groups. The results in Table 4 show the high degree of repeatability of this determination.

IV. DISCUSSION

The productivity of the cows and calves was comparable with that recorded for the same environment by Alexander *et al.* (1960) and Alexander, Beattie, and Sutherland (1964). The climatic and pasture conditions experienced by the cattle in the two years of the present investigation were also comparable with those from the period covered in the aforementioned papers.

The results of this investigation show that the mean hepatic concentrations of vitamin A in the adult grazing beef cattle were five times the mean value of approximately 50 μg/g quoted for cattle in the literature (Moore 1957), two to three times the values found by North American workers in range Hereford cows in an average season (Wheeler *et al.* 1957), and comparable with reserves recorded from beef cattle in a terminal stage of under-nutrition resulting from drought conditions in Queensland (Gartner and Alexander 1966). The results are of the order found in cattle purchased for experimental purposes from commercial beef properties in the Burnett district of Queensland and from Central Queensland (Ryley, Gartner, and Morris 1960; Morris and Gartner 1966, 1967).

Although the mean vitamin A levels found in the calves were adequate and greater than some values quoted for animals of equivalent age (Moore 1957), or weight (Cameron 1966), the levels were appreciably lower than those found in the cows. The latter is to be expected, for unless high doses of vitamin A are given to pregnant cows, the calf is born with low concentrations of vitamin A in the liver (Moore 1957), which increases with age. That is probably why group 1, being older than the other two groups at all sampling periods, had significantly higher concentrations of liver vitamin A.

One calf had a deficient reserve of vitamin A and four other calves had levels which could be considered sub-optimum. These low levels may indicate no more than the concentration which would normally have been reached in the slow increases from neo-natal to adult levels. It is more likely that these particular calves inherently stored vitamin A at a lower rate than others, but this did not affect their rate of body-weight gain.

Support for the suggestion that some calves store vitamin A in the liver at a faster rate or to a greater extent than others is shown by the high degree of repeatability of the liver vitamin A estimates over a period of time even under grazing conditions involving ingestion of a variable amount of carotene. Results of other experiments involving the feeding of essentially carotene-free rations to cattle showed that the magnitude of hepatic vitamin A depletion was related directly to the initial amount of vitamin A in the liver (Page *et al.* 1958; Ryley, Gartner, and Morris 1960; Gartner and Ryley 1962). These results indicate also inherent differences of vitamin A metabolism.

The results from two previous investigations could substantiate the finding of a lower concentration of vitamin A in the livers of grazing animals in summer compared with winter. Gartner (1959) found a marked seasonal variation in the total vitamin A potency of Queensland butterfat. Maximum values occurred between midwinter and early spring and minimum values occurred between midsummer and early autumn. Variations did not appear to be a function of the level of carotene in the pasture ingested by the grazing animal. Subsequently a significant positive correlation was found between vitamin A in butterfat and in liver when beef cattle ingest negligible carotene (Gartner and Ryley 1962). If this correlation applies also in the grazing animal where carotene intake is not limited, one would expect variations in liver to follow variations in butterfat with lower concentrations in summer compared with winter.

There are few data on the effect of vitamin A administration to beef cattle grazing pastures without receiving supplements. Both Chapman *et al.* (1964) and Perry *et al.* (1966) tested vitamin A in fattening rations for steers on pasture where, judging from the amounts of concentrates consumed, grazing was limited. Under these conditions, supplementation resulted in increased rate of gain during two winter experiments but not during one in summer (Chapman *et al.* 1964) and no effect on rate of gain in three experiments on summer pasture (Perry *et al.* 1966). The hepatic vitamin A level in these cattle after supplementation for approximately 3–6 months was still lower than the levels found in our unsupplemented cows. It appears that grazing pastures throughout the year results in these high hepatic reserves. This suggests that vitamin A supplementation is not indicated under the conditions outlined in this paper.

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