CCXLVII. DIURNAL VARIATIONS IN THE BLOOD-SUGAR LEVEL OF THE LACTATING COW.

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LITERATURE relating to the bovine blood-sugar level shows that there is no concord of opinion as to the normal value. Among the earlier workers the average values recorded range from 50 mg. per 100 cc. [Awdejewa *et al.*, 1927] to 82 mg. per 100 cc. [Schwarz, 1928]. Hewitt [1930] reports values of 79–95 mg. per 100 cc. for dry cows and 50–63 mg. per 100 cc. for lactating cows, and quotes average values ranging from 41 to 80–120 mg. per 100 cc. from a number of other workers. Hodgson *et al.* [1932] give an average value of 53 mg. per 100 cc. for cattle over 2 years old, and Turk and Work [1933] give 51 mg. per 100 cc. as their average for lactating cows. While it is conceivable that part of this variability is due to the different methods of analysis employed, the question of the time of sampling must not be lost sight of as a possible factor.

The question of diurnal variation has so far received little attention. Richter [1928] could find no evidence of diurnal variation. Little *et al.* [1928], studied one cow, sampled hourly from 5 p.m. to 9 p.m. and again from 6 a.m. to 4 p.m. the following day, and obtained this sequence of figures: 56, 69, 62, 73 and 66 mg. per 100 cc. for the evening samples and 66, 76, 90, 90, —, 76, 83, 93, 78, 69 and 79 mg. per 100 cc. the next day. Hodgson *et al.* [1932] sampled cows, which were fed at 6 a.m. and 4 p.m., at 7 and 10 a.m. and 1, 3 and 5 p.m., and obtained blood-sugar values of 51.4, 49.0, 50.7, 52.9 and 50.5 mg. per 100 cc. at these hours. Allcroft and Strand [1933] reported higher blood-sugar levels in the evening than in the morning with starving sheep.

EXPERIMENTAL.

In the course of regular sampling for blood considerable fluctuations of blood-sugar level in the dairy cows were observed, notably when a large number of cows were bled on the same day and the time of sampling was extended. The general tendency for the later-drawn samples to exhibit lower levels of blood-sugar suggested that there might be a steady diurnal decrease about this time, which might be part of a diurnal rhythm in the level of this constituent. The following work was therefore undertaken to test the question, the Hagedorn-Jensen blood-sugar technique being employed [1920].

Exp. 1. One cow was sampled hourly from 6 a.m. till 11 a.m. and the blood-sugar values obtained were 68, 67, 65, 59, 51 and 42 mg. per 100 cc., showing a steady decrease which was more marked in its later stages.

Exp. 2. Two cows were sampled hourly from 6 a.m. till 3 p.m., their values for blood-sugar being given in Table I.

Table I.

Time	6 a.m.	7 a.m.	8 a.m.	9 a.m.	10 a.m.	11 a.m.	Noon	1 p.m.	2 p.m.	3 p.m.
Cow 9	78	73	70	65	65	58	55	48	55	64
„ 18	64	54	54	53	68	65	—	42	58	68

These two preliminary tests were sufficiently suggestive to warrant fuller investigation.

Exp. 3. Four cows, Nos. 9, 10, 17 and 18, near the end of their lactation period, were used. Samples were taken hourly from 3 a.m. till 11 p.m. and again, after a period of rest for the cows, from 3 a.m. to 7 a.m. the next morning. Cows 9 and 10 were sampled at the odd hours and cows 17 and 18 at the even hours, so that each cow was sampled every 2 hours. From the data obtained a composite curve was constructed taking at each half-hour the average of the four bloods taken at 7 and 8 o'clock. This curve is shown in Fig. 1 and exhibits a sharp decline from 7.30 a.m. to about 11.30 a.m. followed by a small rise to 3.30 p.m. and subsequent decrease. It was thought that the continual disturbance of the cows might account for the failure of the blood-sugar level to return to its high value in the early morning, and so for subsequent work the technique of sampling was modified.

Fig. 1.

Exp. 4. To minimise the risk of continued disturbance it was decided to extend the experiment over 24 days, sampling only once a day, an hour later

Fig. 2.

--- Dry cows [Exp. 4].
 — Lactating cows [Exp. 5].

Fig. 3.

each day. Previous work (unpublished) had shown that over a period of a week variations up to 16 % of the blood-sugar value were likely to occur when samples were drawn at the same hour each day. Six cows were used and divided into two

lots of three, one lot being bled at the odd hours and the other lot at the even hours, so that each lot of cows was only bled once in two days. The cows were dry at the time of this experiment. A composite curve, constructed as was Fig. 1, is shown by the broken line in Fig. 2.

Exp. 5. This was a repetition of Exp. 4, using the same animals in the same groups, when the cows were in full lactation, some 7 to 10 weeks after calving. Their composite curve is given by the continuous line in Fig. 2.

Exp. 6. To act as a check on the dry cows' curves four dry sheep, two black-faced Highland wethers and two non-pregnant half-bred ewes, were used and sampled hourly over an extended period. Their composite curve is given in Fig. 3.

DISCUSSION.

From the curves given in Figs. 1, 2 and 3 it is safe to conclude that, while there is no apparent diurnal rhythm in the blood-sugar level of dry cows and dry sheep, there is some evidence of a decided trend of diurnal changes in the blood-sugar level of lactating cows. In Fig. 1 the curve falls rapidly from 7.30 a.m. till 11.30 a.m. after which it rises slightly and falls again; its continued low level next morning was suspected to be due to the fact that the animals had been disturbed hourly over the early part of the night at a time when they would normally be quiescent. That this theory was in part at least correct is suggested by the adequate recovery obtained in Exp. 4, Fig. 2, when all possible precautions were taken to avoid unnecessary disturbance of the animals. This latter curve does not exhibit the same extreme fluctuations as does the curve in Fig. 1, nor do the low peaks of the two curves exactly coincide for time of day, but the curves are so strongly similar in character as to suggest the existence of a definite diurnal rhythm in the level of blood-sugar. The fact that no such rhythm is apparent in the curves for dry cows or dry sheep would seem to imply that this rhythm is associated with the state of lactation. This suggestion is in keeping with the work of Filipović [1931], who observed that the rate of secretion of milk increased rapidly to a maximum about 4 to 5 hours after milking and thereafter slowed down again, and of Carlens and Krestownikof [1927], who noted that the level of blood-sugar was high before milking and fell during milking, unless the animal was unduly disturbed by the sampling.

In all the work reported here the schedule of feeding hours was the same and, in the case of lactating animals, the hours of milking were the same.

It is not the purpose of this communication to discuss or theorise over the possible physiological causes of the variations found but rather to emphasise the fact that, especially when dealing with lactating animals, it is highly important to keep the hour of sampling constant when comparable blood-sugar values are required. Further work, designed to discover the factor or factors causing the variation, would be of assistance in interpreting results obtained from various sources.

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REFERENCES.

- Allcroft and Strand (1933). *Biochem. J.* **27**, 512.
Awdejewa, Prowatorowa, Savoitch and Thal (1927). *Biochem. Z.* **187**, 369.
Carlens and Krestownikof (1927). *Biochem. Z.* **181**, 176.
Filipović (1931). *Milchwirtsch. Forschung*, **12**, 347.
Hagedorn and Jensen (translation by Höst and Hatlehol) (1920). *J. Biol. Chem.* **42**, 347.
Hewitt (1930). *J. Amer. Vet. Med. Assoc.* **77**, 362.
Hodgson, Riddell and Hughes (1932). *J. Agric. Res.* **44**, 357.
Little, Keith and Farcus (1928). *Vet. J.* **84**, 284.
Richter (1928). *Biochem. Z.* **194**, 376.
Schwarz (1928). *Biochem. Z.* **194**, 328.
Turk and Work (1933). *J. Dairy Sci.* **16**, 33.