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A comparison of sites for monitoring body temperature of cattle and sheep

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ABSTRACT

Four experiments were carried out to investigate whether temperature measurements recorded continuously from the vagina of ruminant animals are comparable to those measured at the rectum. Normal vaginal, rectal and ruminal temperatures of sheep (n = 4) and cattle (n = 2) were measured twice for 4 h and 2.5 h, respectively. Fever was induced by administration of endotoxin to sheep (0.8 µg/kg live weight, n = 4) and cattle (0.2 µg/kg live weight, n = 2) and the temperatures were recorded for 4 h. Normal vaginal and rectal temperatures were recorded simultaneously in 8 sheep for 2 h and separately in 6 and 12 sheep, respectively, for 4 h. In sheep, mean (± SEM) rectal temperature ranged between 39.1 ^{o}C and 39.4 ^{o}C (± up to 0.11 ^{o}C) and mean vaginal temperature ranged between 39.2 ^{o}C and 39.5 ^{o}C (± up to 0.17 ^{o}C). In cattle, means (± SEM) of rectal and vaginal temperatures were both 38.6 ± 0.10 ^{o}C. Endotoxin elevated temperatures by about 2 ^{o}C and ruminal temperature was occasionally up to 1 ^{o}C higher than rectal or vaginal temperature. Rectal and vaginal temperatures did not differ significantly from each other in either species. The findings indicate that, for monitoring the internal thermal environment of cattle and sheep, vaginal temperature is equivalent to rectal temperature and support other evidence that temperature of the rumen can be independent of body temperature.

Keywords: core body temperature; rectal temperature; vaginal temperature; ruminal temperature; sheep; cattle.

INTRODUCTION

Recently, concern about possible thermal stress in female ruminant animals has initiated studies where continuous measurements of body temperature have been carried out using recording devices inserted in the vagina (e.g. Bluett *et al.,* 2000). For clinical purposes and in most previous studies, body temperature has typically been monitored by taking rectal temperature (T_R) measurements, so the relevance of records from vaginal measurements (T_V) needs to be ascertained. The data of Bluett *et al.* (2000) and our own (unpublished) from lactating dairy cows show major oscillations of T_V that are assumed to reflect changes in core body temperature, but there is little information available to confirm this assumption. T_R and T_V have been measured simultaneously in just a few studies of cattle (Grant *et al.,* 1942; Huhnke and Monty, 1976; Matsui, 1995) and apparently none in sheep. Although these studies have shown that there is almost no difference between T_R and T_V, the literature overall does not provide a solid basis for this finding.

The experiments conducted here were carried out to provide more information about whether vaginal temperature (T_V) reflects that measured at the rectum (T_R). In addition, ruminal temperature (T_{RU}) was measured to provide contrasting data from a region of the body where temperature occasionally varies from that recorded at other sites (Prendiville *et al.*, 2002).

MATERIALS AND METHODS

Animals

Sheep were non-pregnant adult Coopworth ewes either held on pasture at the Lincoln University Research Farm and brought into indoor pens for the measurements or housed in indoor pens. The cattle were two rumen-fistulated 12-year-old Angus cows held on pasture at the farm and brought into a yard for the measurements. Ruminal fistulation of the cattle and of four sheep had been carried out under aseptic surgical conditions for earlier experimental studies that were not related to the present study. All use of animals in these experiments was approved by the Lincoln University Animal Ethics Committee.

Experimental procedures

Experiment 1

T_R, T_V and T_{RU} were measured simultaneously on 2 runs in sheep (n = 4) for 4 h and cattle (n = 2) for 2.5 h in winter, commencing at approximately 10:00 h (New Zealand Standard Time) each day.

Experiment 2

T_R, T_V and T_{RU} were measured simultaneously in sheep (n = 4) and cattle (n = 2) in winter, commencing at approximately10:00 h. At about 1.5 h later all animals were given an i.v. injection of endotoxin (*Escherichia coli* 055:B5 lipopolysaccharide, Sigma Chemical Company, St Louis, Missouri, United States of America) at a dose of 0.8 and 0.2 µg/kg live weight for sheep and cattle, respectively, and temperature measurements were recorded for a further 4 h.

Experiment 3

T_R and T_V were measured simultaneously in sheep (n = 8) for 2 h in winter, commencing at approximately 10:00 h.

Experiment 4

In a separate study, T_R (n = 12) and T_V (n = 6) were measured at the same time for 4 h in summer commencing at approximately 09:00 h (New Zealand Daylight Time).

Measurements

Experiments 1, 2 and 3

T_R, T_V and T_{RU} were measured every 3 minutes using a temperature sensor and data logger (7.0 by 1.5 cm, 'Minilog' – Vemco Limited, Nova Scotia, Canada) that had an accuracy within $\pm$ 0.1 ^oC. In sheep, data loggers were inserted 14 cm into the vagina and for rectal measurements data loggers were mounted on a ewe bearing retainer (Shoof International Limited, Cambridge, New Zealand) and inserted 10 cm into the rectum. In the cattle, data loggers were inserted 14 cm into the rectum and, for vaginal measurements, were mounted on a progesterone-free CIDR-B™ (InterAg, New Zealand Limited, Hamilton, New Zealand) and inserted 32 cm into the vagina. In Experiments 1 and 2 data loggers were inserted 15 cm into the rumen via a pre-existing cannula. Ambient air temperature (mercury thermometer) varied between 5 and 10 ^oC.

Experiment 4

T_V of 6 sheep was measured every 30 minutes using a radiotelemetric device (5.5 by 1.0 cm, Advanced Telemetry Systems Inc., Isanti, Minnesota, United States of America) mounted on a progesterone-free CIDR-G™ that was inserted about 12 cm into the vagina. T_R of 12 other sheep was measured using a digital clinical thermometer (Geratherm Plus, model 2020, Geratherm Medical AG, Geschwenda, Germany) that was inserted about 11 cm into the rectum for each reading. Ambient air temperature (mercury thermometer) varied between 16 and 20 ^oC.

Statistical analysis

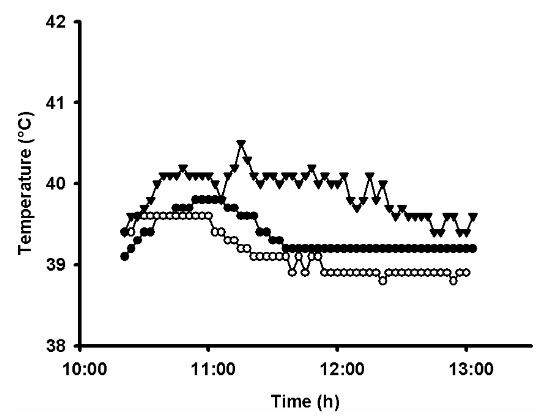
Temperatures measured at the different sites were compared by ANOVA using MINITAB® Release 14.1 (Minitab Inc., State College, Pennsylvania, United States of America). Normal temperatures from Experiments 1 and 2 were analysed using data pooled from Experiment 1 and from Experiment 2 before endotoxin was given. Post-endotoxin temperature analysis (Experiment 2) was performed on data commencing 30 minutes after injection to avoid the effects of handling. Temperature means for each site, reported as mean $\pm$ SEM, were the averages of the single mean temperature recorded for each animal.

RESULTS

Experiment 1 – normal temperatures (sheep and cattle)

In sheep, T_R ranged between 38.1 and 40.0 ^oC (mean, 39.3 ± 0.11 ^oC, 4 sheep, 2 runs) and T_V ranged between 38.4 and 39.8 ^oC (mean, 39.5 ± 0.17 ^oC, 4 sheep, 2 runs). T_R and T_V did not differ from each other (P = 0.39) but T_{RU} was generally about 0.5 ± 0.16 ^oC higher (P < 0.05). (Figure 1 shows data from one animal.)

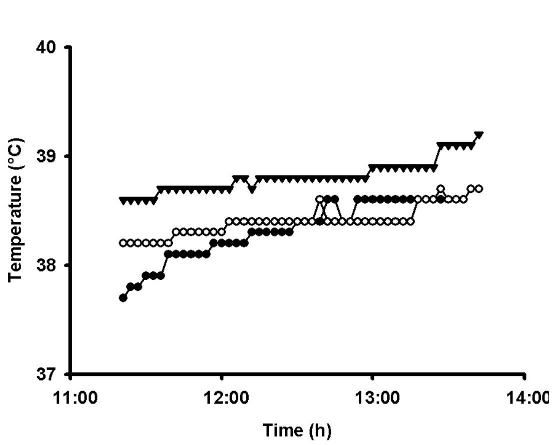
FIGURE 1: Rectal (●), vaginal (○) and ruminal (▼) temperatures recorded simultaneously from a representative ewe every 3 minutes while the animal was held indoors.



In the case of one sheep that was observed to take a drink of water at 10:52 h, T_{RU} fell from 40.1 to 38.2 ^oC during the next 18 minutes and there was a smaller (0.8 ^oC) decrease in T_R that lasted about 25 minutes.

In cattle, T_R ranged between 37.6 and 38.9 ^oC (mean, 38.6 ± 0.10 ^oC, 2 cows, 2 runs) and T_V ranged between 37.7 and 38.7 ^oC (mean, 38.6 ± 0.07 ^oC, 2 cows, 2 runs). T_R and T_V did not differ from each other (P = 0.68) but T_{RU} was generally about 0.5 ± 0.18 ^oC higher (P < 0.05). (Figure 2 shows data from one animal.)

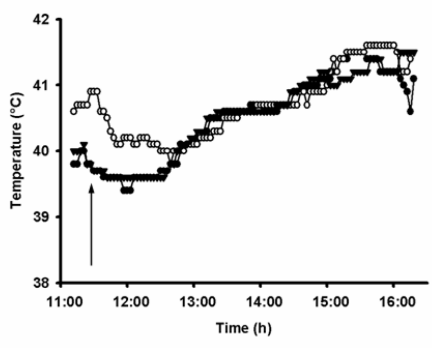
FIGURE 2: Rectal (●), vaginal (○) and ruminal (▼) temperatures recorded simultaneously from a cow every 3 minutes while the animal was held outdoors.



Experiment 2 - elevated temperatures (sheep and cattle)

Temperatures increased up to 2.0 °C after administration of endotoxin in cattle and sheep, but there was no difference between T_R and T_V at any single time during the period of the induced fever (which commenced about 1 h after injection of endotoxin, Figure 3).

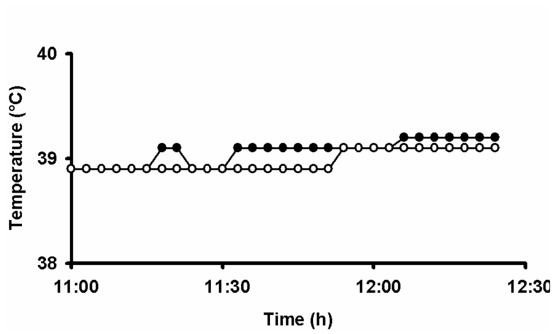
FIGURE 3: Rectal (●), vaginal (○) and ruminal (▼) temperature recorded simultaneously every 3 minutes from a ewe treated with endotoxin (at time indicated by the arrow) while the animal was held indoors. (Note: the high values for T_V recorded from this particular animal during the first hour appear to be an anomaly.)



Experiments 3 and 4 – normal temperatures (sheep)

In sheep (n = 8), mean T_R and T_V were 39.1 ± 0.07 °C and 39.2 ± 0.07 °C, respectively, during winter and did not differ significantly from each other (P = 0.48); differences were often within data logger error (± 0.1 °C) (Figure 4). During summer, mean T_R was 39.4 ± 0.04 °C (n = 12), mean T_V was 39.2 ± 0.11 °C (n = 6), and these also were not different from each other (P = 0.07).

FIGURE 4: Rectal (●) and vaginal (○) temperatures recorded simultaneously from a representative ewe every 3 minutes while the animal was held indoors.



DISCUSSION

These results show that T_R and T_V are generally similar to each other in both cattle and sheep. Also they showed that this relationship was not affected by the use of different types of measuring device or technique, nor was it affected by the marked elevation of body temperature that was induced by administration of endotoxin. In the case of cattle, this finding strengthens that reported by Matsui (1995) by providing data from two more animals recorded at normal ambient temperatures and for sheep this appears to be the first report specifically comparing the two sites.

The three published studies on cows in which T_R and T_V were compared directly reported that T_R was often higher than T_V but not significantly so (Grant *et al.,* 1942; Huhnke and Monty, 1976; Matsui, 1995). However, the lack of difference between means of T_R and T_V within either cattle or sheep in the present study reinforces the non-significance of these observations. Nevertheless, on 2 out of 34 occasions during this study, T_V was recorded as up to 1.2 °C higher than T_R in sheep, e.g. as in Figure 3. Although this may have been due to local temperature fluctuations at one or other of these two sites, the occurrence of such events was rare and they may just be anomalies for which there is no available explanation.

Temperature measurements taken at different sites throughout the body can vary considerably from each other (Eichna *et al.,* 1951; Bligh, 1955; Lefrant *et al.*, 2003). In the case of the rumen, the temperature (T_{RU}) recorded in this and other studies (Dale *et al.,* 1954; Prendiville *et al.,* 2002) was significantly higher overall than T_R and T_V. One cause of this is the microbial activity in the rumen (Noffsinger *et al.,*1961). T_{RU} can also be affected by ingestion of cold feed or water causing a drop in local temperature of the rumen and, sometimes, of T_R (Noffsinger *et al.,* 1961; Bailey *et al.,* 1962; Cunningham *et al.,* 1964). In the case of T_{RU}, one such event was recorded in the present study. Obviously, ruminal temperature is highly variable for reasons other than changes in core body temperature, so the measurements recorded in the present case show this and highlight the relative stability of vaginal and rectal temperatures in spite of the proximity of these latter organs to the rumen.

During this study several of the animals defaecated whilst the recording devices were in position in the rectum. On many of these occasions in sheep and on all such occasions in cattle the devices were displaced, causing loss of data. In contrast, the vaginal data loggers remained in place throughout each recording session. This observation indicates that in female ruminant animals measurement of T_V may provide more complete data sets than use of T_R. Also, Grant *et al.* (1942) have shown that the temperature of the faecal mass that passes through the rectum is lower than that of the rectal mucosa and Minett and Sen (1945) reported that T_R decreased by 0.5 ^oC in cows that defaecated during their study. Therefore, even if data loggers are not displaced from the rectum by faeces, T_R may still be affected by defaecation. This means that T_V may be a more reliable site for measurement of body temperature because it is likely to provide fuller data sets and does not appear to be affected by factors such as defaecation, feeding or drinking.

The key issue of this work is the relevance of these readings of vaginal and rectal temperature to actual core body temperature, but this could not be addressed directly in the present study. Lowe *et al.* (2001) used T_V and ear canal temperature as indices of core body temperature in sheep and found that mean T_V was 0.4 ^oC higher than mean ear canal temperature, but both measurements fluctuated in concert and with similar daily amplitudes. These authors argued from the basis of the scientific literature that the tympanic membrane has become the site of choice for measurement of core body temperature, however they were of the view that ear canal temperature closely follows core body temperature and, as their data showed, the latter measurement was closely matched to T_V.

There are other views on appropriate sites for measuring body temperature. For instance, it has been suggested (Bligh, 1998) that the temperature of the mixed venous blood in the pulmonary artery (T_{PA}) is truly reflective of mean deep body temperature because this blood has received drainage from all regions of the body as well as being exposed to the inner depths of the trunk, thus reflecting the averaged thermal picture inside the animal's body. Rectal temperature has been shown to represent T_{PA} in humans (reviewed by Mcilvoy, 2004) and carotid artery blood temperature in calves (Bligh 1955), although it was slightly higher in both cases. These findings and others have justified the widespread use of T_R both as a clinical tool and for research of body temperature changes of humans and animals. The results of the present study indicate that T_V and T_R both provide equally relevant data about the thermal status of ruminant animals, although they may tend to overestimate slightly the actual core body temperature and probably lag behind changes in it (Bligh, 1955, 1957; Maxton *et al.,* 2003). Certainly for practical purposes, T_R or T_V should be viewed as being equally reliable indicators of core body temperature that are likely to enable interpretation of changes in thermal status of animals to be performed without the need for invasive and logistically difficult procedures.

In conclusion, for the majority of the time, T_R and T_V are similar to each other and are probably equally reliable as indicators of core body temperature, which justifies their use for this purpose. T_V measurements may provide more reliable data than measurements of T_R as the vagina is not affected to the same extent as the rectum by factors such as defaecation or feeding and drinking. Also, the vagina is easily accessible and data loggers can be inserted for long-term experiments without the need for surgery, but of course is limited to females. These studies help provide confidence that the episodic changes in T_V recorded in recent studies of lactating dairy cows in New Zealand (Bluett *et al.,* 2000; ourselves, unpublished) are likely to represent actual changes in core body temperature.

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