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Daily rhythms of body temperature around lambing in sheep measured non-invasively

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ABSTRACT

Fifteen ewes had data-loggers affixed under the tail, programmed to record temperature (T) every 5 min, storing up to 72 h of data. Ewes were monitored to identify time of lambing (time 0). Lambing period lasted 5 d; thereafter seven ewes which yielded data for 24 h before and after lambing were selected. Mean T (±S.E.M.) was 39.03±0.02°C. Mean T in the 24 h preceding lambing (38.68±0.02°C) was lower than it was in the 24 h following parturition (39.38±0.03°C) ($P< 0.0001$). T was lower in the 12 h preceding lamb birth (38.56±0.10°C) than it was in the previous 12 h (−24 to −12, 38.76±0.02°C) ($P<0.0001$); thereafter, T was lowest precisely at parturition (mean T = 38.18±0.03°C) and increases rapidly and peaked (mean T = 39.70±0.04°C) 2 h after lambing. In the 12 h following delivery (39.28±0.02°C), T increased, especially in the window +12 to +24 h (39.51±0.03°C). In conclusion, T of ewes changed around parturition, with a reduction 12 h before lambing, followed by a rapid increase in the hours following parturition. The data-loggers used proved a high degree of sensitivity to detect physiological T changes, which confirmed that they are appropriate for use in sheep studies.

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1. Introduction

An animal's temperature (T) is the result of the balance between the heat produced by basal metabolism and muscular activity of the body, and the heat lost from the body (De et al. 2017). Traditionally, rectal T has been used to measure the thermal body status of sheep; however, the common technique of inserting a lubricated thermometer into the rectum is invasive and might induce an increase in body T by causing stress, which increases during pregnancy (Vicente-Perez et al. 2016). In addition to the development and implementation of technical solutions, focus has increased on the use of non-invasive and continuous measurement of body core T in animals (Godyń et al. 2019). Changes in body T can provide valuable information about animal-environment interactions and changes in body T the physiological and behavioural status of animals (Pascual-Alonso et al. 2017). In that context, button data-loggers have been used to

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record body T , through surgical implantation, insertion into the gastrointestinal tract or ear canal, or attachment to the animal's skin (Roznik and Alford 2012).

Non-invasive devices have been used to record T and predict parturition based on changes in T in cows and mares, species that have a higher economical value than sheep, and that usually require a more intensive veterinary attention. Intravaginal recording devices, based on telemetry have been used in cows (Aoki et al. 2005; Sakatani et al. 2018) and mares (Masko et al. 2018). In previous studies, we tested several methods for measuring body T in sheep such as subcutaneous T by radio-frequency, T-sensitive transponders inserted under the skin, ocular surface T by infra-red-thermal photography, vaginal T by data-loggers inserted into the vagina, and rectal T by rectal thermometer (Abecia et al. 2015; Pascual-Alonso et al. 2017). We concluded that the tail area seems to be the best location for subcutaneous transponders in sheep.

Studies have shown that body T decreases a few hours before parturition in several species (sheep: Nabenishi and Yamazaki 2017; cows: Aoki et al. 2005; mares: Masko et al. 2018; dolphins: Terasawa et al. 1999); however, few studies have documented T changes after delivery (pigs: King et al. 1972; dogs: Zonturlu et al. 2008, mice: Gamo et al. 2013) and, indeed, no data are available for sheep regarding changes in T in the post-partum period. The aim of this study was to measure changes in body T in sheep before and after lambing, using iButton devices attached under the tail of the ewe.

2. Material and methods

The study was conducted at the experimental farm of the University of Zaragoza, Spain (41°N). All procedures were approved by the in-house Ethic Committee for Animal Experiments from the University of Zaragoza. The care and use of animals were performed according to the Spanish Policy for Animal Protection RD1201/05, which meets the European Union Directive 2010/63 on the protection of animals used for experimental and other scientific purposes.

2.1. Animals and data collection

Fifteen Rasa Aragonesa ewes, which were synchronized in oestrus and artificially inseminated on 25 May, received a data-logger (DS1921K ThermochronTM iButton®, Maxim Integrated, USA) under the tail, affixed by adhesive tape (Figure 1), 145 d after insemination. Data-loggers were programmed to record T data every 5 min and were capable of storing up to 72 h of data. Changes in T were analysed using T analysis software (ExpressThermo 2007®). At the expected time of lambing, ewes were monitored to document the actual time of lambing of each ewe (time 0). The lambing period of the entire group of animals lasted 5 d; therefore, seven ewes were selected from the initial group of ewes at the end of the lambing period, which yielded a complete set of T data for at least 24 h before and after lambing.

Figure 1. Data loggers used to measure and record physiological temperature in Rasa Aragonesa ewes, which were affixed to the animals with adhesive tape under the tails.

2.2. Statistical analysis

Time series data were analysed using a repeated measures test. Mean values 24 h before lambing (24 h to 0 h) and 24 h after lambing (+1 h to +24 h), and within 12-h windows (-24 h to −12 h, −11 h to 0 h, 1 h to +12 h, and +13 h to +24 h) were calculated and evaluated statistically by paired-samples t-tests.

3. Results

Mean T (±S.E.M.) of the ewes was 39.03 ± 0.02°C. Mean T in the 24 h preceding lambing (38.68 ± 0.02°C) was significantly lower than it was in the 24 h following parturition (39.38 ± 0.03°C) ($P < 0.0001$). Mean T differed significantly ($P < 0.0001$) among the four 12-h periods

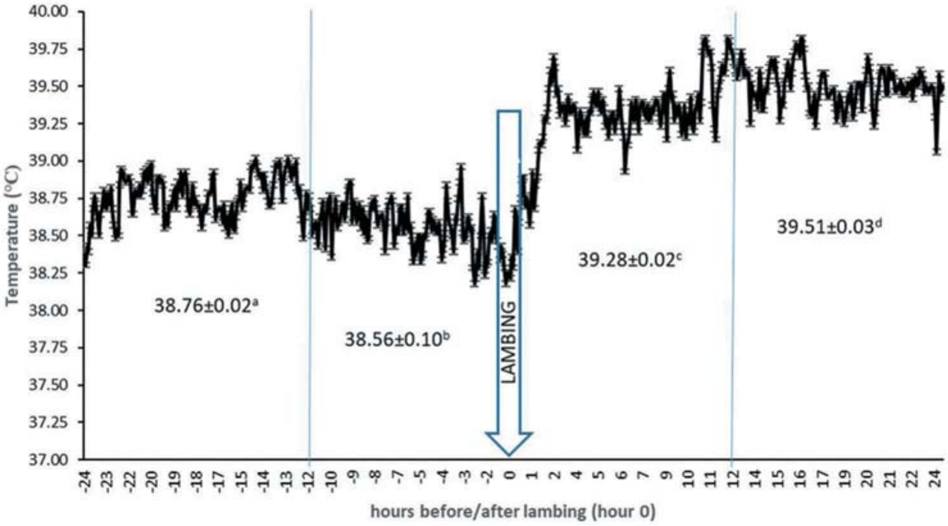

Figure 2. Mean (±S.E.M.) body temperature of seven Rasa Aragonesa ewes from 24 h before to 24 h after lambing (time 0). Mean values of 12-h windows were calculated. Different superscripts indicate significant differences ($P < 0.0001$).

(Figure 2); specifically, ewes experienced a significant decrease in their T in the 12 h preceding lamb birth and was lowest precisely at parturition (mean = e 38.18 ± 0.03°C); thereafter, their T increased and peaked (mean = 39.70 ± 0.04°C) 2 h after lambing. In the 12 h following delivery, T increased, which was most pronounced in the window +12 to +24 h.

4. Discussion

The main results of the experiment are not limited to the identification of the decrease in body T before lambing in sheep but include the post-lambing increase in T up to 24 h after lamb delivery, which has not, to our knowledge, been described in this species. Other studies have described the decrease in T before parturition, only, in the rectum (Ewbank 1969; Winfield and Makin 1975) or body surface (Nabenishi and Yamazaki 2017) of sheep, in cows (Aoki et al. 2005), and dolphins (Terasawa et al. 1999) in the rectum, and in the vagina of mares (Masko et al. 2018); however, no studies have reported T in the hours after parturition. In mares, vaginal T 1 h before and at foaling were significantly lower than it was at the same time of day in the six days prior, and T tended to decrease between −15 h and −2 h (Masko et al. 2018). In the dolphin study, rectal temperatures were recorded at least once per day late in the pregnancy, which indicated that T decreased by 0.7°C to 1.3°C between 24 h and 12 h 12 h pre-partum, and T was significantly lower than the average from 10 d to 1 d pre-partum.

A post-partum increase in T after lambing has been reported in species other than sheep. In sows, King et al. (1972) indicated that body temperature was subnormal before farrowing and, thereafter, body temperature increased significantly, coincident with parturition. They concluded that the extremely high body T of some of the clinically normal post-partum animals indicated that pyrexia, in the absence of other clinical signs, should not be taken as evidence of disease. In the same species, Littledike et al. (1979) reported an increase in body T (1.4° C) associated with parturition; specifically, the increase in body T of the sows began about 12 h before the first pig was born and peaked 1–2 h after delivery of the last pig. Two days post-partum, mean body temperature was about 1°C higher than it was in the pre-partum period, and mean body T increased 0.06°C per day in the 12-day post-partum period. A similar pattern in T pre- and post-partum have been observed in the dog (Zonturlu et al. 2008), specifically bitches experienced a decrease in rectal T 144 h before whelping, at which point T increased. In mice (Gamo et al. 2013), body T increased abruptly after parturition.

Evidently, progesterone is involved in the maintenance of T during pregnancy (Suthar et al. 2012); therefore, it is likely that the pre-partum decreases in T observed in several mammal species is associated with the reduction in the luteal support at the end of pregnancy. Although that pre-partum decrease in T might be a result of changes in circulating progesterone, little information is available on the sudden increase in T immediately after delivery. Prolactin secretion, which is involved in the induction and maintenance of milk production, might be indirectly associated with the increase in T after lambing (see review by Svennersten-Sjaunja and Olsson 2005). In mice, the heat generated from milk synthesis is equivalent to 44% of gross energy intake at 21°C (Johnson et al. 2001), which might be a factor that contributed to the increase in T observed in Rasa Aragonesa ewes.

An objective of our study was to confirm whether temperature-recording buttons can be used as a non-invasive method for measuring the body temperature of ewes before, during, and after birth. Other studies have indicated that sheep body T measured at the perineum, the axillae, and the inner thigh are strongly correlated with rectal temperature (Mendes et al. 2013); however, those areas can be affected considerably by the ambient temperature (Miranda-de la Lama et al. 2018). We measured T under the tail because it is easier to affix the logger where there is little hair and "that location offers protection from the outside temperature. An advantage of that method is that it does not interfere with any physiological process of sheep (e.g., intrauterine sensors), and can remain clean, intact, and operational.

5. Conclusion

In conclusion, this study has demonstrated that the body T of ewes changes around parturition such that they experience a decrease 12 h before lambing, and a rapid increase in the hours following lamb birth. In addition, the data-loggers used in this study were shown to been highly suitable for detecting changes in physiological T in sheep.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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