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# Vaginal temperature measurement by a wireless sensor for predicting the onset of calving in Japanese Black cows

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ABSTRACT

We evaluated the utility of the continuous measurement of vaginal temperature by a wireless sensor and wireless connection for predicting the onset of calving and for clarifying the relationships among dystocia, calf conditions, and temperature changes at a commercial beef cattle farm in Japan. A total of 625 effective delivery data was collected. The temperature sensor inserted to the vagina on 7 days before the expected due date and collected the vaginal temperature every 5 min. The sensor detected two alerts according to the temperature change, one was the vaginal temperature of 4 h moving average compared to the same time temperature of last two days decreased more than 0.4 °C (Alert 1) and the other was the rupture of the allantoic sac and the dropped sensor temperature reached to the ambient temperature (Alert 2). The detection rates of Alert 1 and Alert 2 were 88.3% and 99.4%, respectively. The average time between Alert 1 and Alert 2 (Time 1) was 22 h, and that between Alert 2 and delivery (Time 2) was 2 h. These results indicated that the continuous measurement of vaginal temperature is effective for predicting the calving time. The necessity of assistance was correlated with dystocia, calf birth weight (BW), sex, and gestation periods. Interestingly, the durations of Times 1 and 2 were also associated with dystocia. The calf BW, sex, and gestation periods affected the length of Time 2. Our findings indicate that the BW of the calf is the most important factor for dystocia risk, and that the continuous measurement of vaginal temperature could become a good indicator for predicting not only the onset of calving, but also the necessity of assistance.



## 1. Introduction

Calving management is important for cattle farmers toward their goal of maintaining stable farm management. Calving often starts at night (42–46%), requiring extra labor for farmers [1–3]. In addition, fetal death and dystocia are major issues in dairy and beef cattle calving because they inflict serious effects on both economic and non-economic components of farm management [4]. As a farm becomes larger, calving becomes a greater problem [4]. Therefore, the prediction of the onset of calving would be crucial to reduce farmers' labor costs, the incidence of parturition accidents, and the need of calving assistance.

The parturition process, which may involve the problems of prolonged calving or dystocia, highly affects the well-being of the calves [5–7]. Dystocia is a major cause of fetal death or death of calves after delivery [8,9]. Moreover, it does harm to maternal reproductive organ, such as uterus and vagina and leads to problems in subsequent pregnancies, e.g., a delay of breeding and an increase in the incidence of miscarriage [6,10–12]. In dairy cattle, the incidences of dystocia and assisted calving (including primiparous and multiparous deliveries) are approx. 6.8% and 31%, respectively [13]. In Japan, 8.5% of calving in Japanese Black cows involved dystocia [14].

Beef calves born from primiparous dams showed higher mortality compared to calves from multiparous mothers after birth

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because of a higher dystocia rate [9]. To decrease the rates of fetal death or death of calves, it is thus necessary for farm staff to be present at the scene of delivery and to provide appropriate assistance. Therefore, being able to predict and announce the onset of calving is strongly desired in the dairy and beef industries [15].

Signs such as the relaxation of pelvic ligaments, udder edema, and teat filling have been used as indicators of delivery [16]. These are good markers but not precise enough to determine the exact time of delivery [17]. The advantage of using an electric data logger for predicting the onset of delivery without restraint has been recently reported [18]. Although Titler et al. (2015) showed that the observation of behavioral activity was effective for predicting calving, these behavioral changes are observed only at 6–12 h prior to calving [18].

Detecting the regression of the pregnant corpus luteum could be a good indicator for predicting calving [19,20]. The body temperature of cattle has been reported to well reflect hormonal changes, especially the progesterone concentration [21,22]. Many studies showed that the body temperature of cattle decreased one day before delivery [16,23–30], and this change is thought to reflect the corpus luteum regression and the decrease of the progesterone concentration [19]. Moreover, the detection of the time of the vaginal temperature decrease is a good indicator to predict calving [27,29]. However, detecting this decrease was not effective to determine the onset of calving precisely.

Wireless temperature measuring devices are now used in the livestock industry [31,32]. This technology enabled the easy monitoring of the body temperature of cattle without the need for restraint, and with such a device farmers can also check the temperature data remotely [32]. However, few studies have investigated the practical utility of using a temperature sensor for predicting the onset of calving on a large scale at a commercial farm [32].

Here we evaluated whether the continuous measurement of vaginal temperature using a wireless system is useful for detecting the onset of calving at a commercial beef cattle farm. We also investigated the relationships between vaginal temperature changes and various calving conditions such as dystocia.

## 2. Materials & methods

The experiment was conducted from June 2014 to November 2015 at a commercial beef cattle farm (Kanoya city, Kagoshima, Japan), which kept approx. 500 Japanese Black cows for breeding. All experimental procedures were approved by the Animal Experimental Committee of Kyushu Okinawa Agricultural Research Center, NARO.

### 2.1. Animals

Pregnant Japanese Black cattle (3–7 years old, 1 to 5 parities) were moved to individual 16-m$^2$ maternity pens 3 weeks prior to the due date. They were fed 14 kg of total mixed ration (TMR) in the evening (once a day at approx. 4:00 p.m.), and water was provided ad libitum. A total of 669 deliveries were observed during the experimental period.

### 2.2. Vaginal temperature measurement

Seven days prior to the expected due date, the cow's vulva was cleaned with invert soap and 70% ethanol, and a clean vagina temperature sensor (Fig. 1, Gyuonkei, Remote Inc., Oita, Japan) was inserted into the vagina. The vaginal temperature was recorded by the sensor every 5 min, and the collected data were immediately sent to the company server by WIFI connection (NTT DOCOMO, Tokyo). The temperature data were stored at the server, and every 4 h the moving average temperature was calculated automatically. The moving average temperature was also compared with those at the same time on the prior 2 days. The first alert (Alert 1) of temperature change was issued by the server when the temperature difference was higher than the threshold (0.4 °C). A second alert (Alert 2) was issued when the sensor dropped out of the cow's vagina due to the rupture of the allantoic sac and the temperature decreased to the ambient temperature.

These data could be checked on a website using the cloud system or by having the alert messages sent to an email address. The exact time points of Alert 1 and Alert 2 and the delivery time of all parturitions were recorded, and the interval between Alert 1 and Alert 2 (Time 1, h:mm) and the interval between Alert 2 and the delivery (Time 2, h:mm) were calculated manually.

### 2.3. Parturition data

The reproductive history (parity) and the date of artificial insemination (AI) of each cow were recorded. The gestation period and differences (days) from normal Japanese Black cows' gestation period (285 days) [33] were calculated.

To determine the effects of the dystocia level on the calving time, we divided the parturition status into three categories: non-assist (spontaneous delivery); mild dystocia = assisted by a farm worker; and severe dystocia = assisted by more than two people including a veterinarian. We also categorized the calving season into spring (Mar to May), summer (Jun to Aug), autumn (Sept to Nov) and winter (Dec to Feb). The calves' sex and birth weight (BW) and the numbers of fetal deaths and twin deliveries were also recorded.

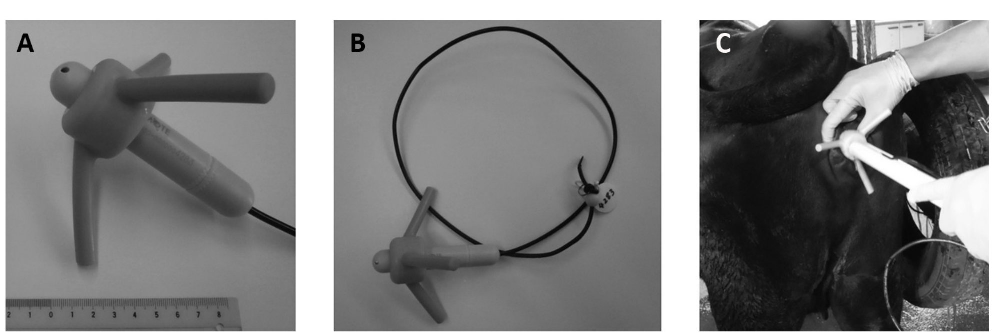


**Fig. 1.** The Gyuonkei vaginal temperature sensor. The sensor was attached with a stopper (A) and the antenna cord (B). The sensor was inserted into the cow's vagina by using the included attachment (C).