Devices to Identify the Stage II of Labor

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Cattle farming is facing an increase in number of animals that farmers must care for, together with decreasing time for observation of the single animal. Remote monitoring systems are needed in order to optimize workload, calving assistance, first neonatal care and animal welfare. The expulsive phase is characterized by the complete dilation of birth canal, fetal sacs rupture, fetus entering the canal together with intense and coordinated uterine and abdominal contractions. Sensors for the detection of the stage II of labor can be divided into two main categories: external devices which are sutured to the vulvar skin, and intravaginal sensors.

cattle calving prediction remote monitoring calving assistance calving alert stage II parturition

1. Vulvar Magnetic Sensors

Vulvar lips separation during labor can be detected through magnetic sensors which are sutured to the vulva skin, as routine in equine practice (Foalert, Acworth, GA, USA; C6 birth control, Sisteck s.r.l., Sassuolo, Italy) [1][2]. Marchesi et al. [3] evaluated Se and PPV of Foalert as a calving alarm in 53 Holstein Friesian cows, which were found to be 100% and 95% respectively. They also reported that the presence of farm personnel at calving reached 100% in alarmed cows, compared to 17% in controls ($p < 0.001$). This system has been further paired to a GPS-transmitter included in neck collars of grazing dairy and beef cattle [4]. In grazing systems, GPS localization and calving alert could be useful both for ensuring assistance, first neonatal care, and to avoid calf losses due to predation. Although those devices proved to be suitable for correct identification of parturition in cattle, the application of the device is invasive and requires veterinarian supervision due to the necessity of a local anesthesia for the suture of the components to vulva surface. This technology has been evaluated as expensive for its application in cattle breeding operations, due to purchase and maintenance costs [5][6].

2. Intravaginal Devices

Some intravaginal thermometers are able to recognize both the pre-calving drop in dam's body temperature and their own expulsion when fetal sacs or the fetus enter the birth canal. The T-shaped calving alert iVET® (iVET®—Geburtsüberwachung für Kühe, 2012) is characterized by a light-sensor and has been evaluated for use in Holstein primiparous [7]. Sensitivity (Se) and specificity (Sp) of the iVET® were 0.78 and 0.93, respectively. Although the device correctly warned the farm personnel, poor local tolerance was observed, as irritation and discomfort were noticed. Moreover, interference with the parturition process was hypothesized, as the shape of the device could be responsible for premature rupture of fetal sacs, delayed birth canal dilation and increased dystocia rate (58.3% and 40.9% in experimental and control primiparous, respectively, $p < 0.001$).

The Medria (Vel'Phone®, Châteaugiron, France) and the Gyuonkei (Gyuonkei, Remote Inc., Oita, Japan) are temperature sensors able to generate both an alert at approximately 24 h before delivery (decrease of 0.4 °C of vaginal temperature), and a calving alarm when the devices are expelled [8][9][10][11]. However, one of the major concerns when using devices only equipped with thermometers is that the differential between the dam's temperature and the external environment could be not enough to generate the alert, as introduced by Norman et al. [5]. They described the use of a remote calving alert in deer, elk, bison and antelope (Sirtrack Ltd., Havelock North, New Zealand), but the detection of expulsion could be impaired for example in hot-climate conditions, as in cattle in case of heat stress.

The intravaginal device OraNasco (Kronotech Srl, Campoformido, Italy) overcomes the single-parameter issues since it is equipped with physical sensors for both light and temperature. The temperature sensor is set to recognize gradients. The light sensor is able to generate an output even in case of scarce brightness. When the device is inserted into the vaginal canal, the probe detects light or a sudden change in temperature. If at least one of the two conditions is present, the probe switches to the ejected status and communicates the expulsion to the Central Unit. The expulsion of the probe occurs when the fetal sacs or the fetus itself enter the birth canal, at the beginning of stage II of labor. Then, the Central Unit sends alerts to farm personnel through GSM, LAN and Wi-Fi connection. The remote system has been evaluated for use both in cattle [12] and buffaloes [13]. Field trials demonstrated an overall Se = 86.3% [14], a good local tolerance and a high retention rate, except in one case of recurrent vaginal prolapse in a buffalo heifer.

Watanabe et al. [15] evaluated the potential of an intravaginal device composed of a triaxial accelerometer coupled to a continuous radio-emitting body. Once expelled, the radio signal is no longer dampened by the body tissues, while the accelerometer identifies the falling. The combination of those data is commuted into the calving alarm by the Central Unit. The identification of stage II of calving was reported to occur correctly for both the triaxial and radio signal methods, although no further information is available concerning the local tolerance or field use of this device.

The majority of the products described above are not designed for use in grazing herds, as the central unit is to be placed within a range from periparturient cows. Due to the dispersal of herds in extensive Australian pasture-based systems, a telemetric intravaginal calving alert device is under evaluation in beef cattle [16]; the device is equipped with a Taggle™ mother board which emits a radio signal ping when expelled. The radio ping can be telemetrically triangulated and the position localized within the pasture. Preliminary results showed an 85% retention rate and no local adverse effects. Correct identification of calving was reached in 66% of deliveries while localization of animals was achieved in 64% of cases with an approximation of 100–200 m. Tracking parturient animals in extensive grazing areas is a concern in Australian breeding systems. Placing radio receiving antennae could be difficult due to the ground topography; thus researchers are also evaluating a Vaginal Implant Transmitter (VIT) device which is equipped with temperature and accelerometer sensors coupled to a GNSS collar for tracking via satellite technology [17]. The device is still a prototype at present, and more improvement is needed for field use.

Table 1. Devices for calving alarm which identify the onset of stage II of parturition, with performance and references.

Event	Sensor type	Device	N	Application	TI	Device performance	Factory	References
Vulvar lips separation	Magnetic sensor	Foalert, C6 birth control	22 80 53	Vulva (suture)	0 h	Se = 100; PPV = 95%	Sisteck Srl, Sassuolo, Italy https://www.foalingalarm.net/	Paolucci et al. [1] Paolucci et al. [6] Marchesi et al. [3]
	Magnetic sensor and GPS collar	GPS-CAL	26	Vulva (suture) + neck collar (GPS)	0 h	Se = 100%; PPV = 100%	Sisteck Srl, Sassuolo, Italy SiRF Technology, San Jose, California, USA	Calcante et al. [4]
Device expulsion	Light and temperature	OraNasco®	120 15 117 83	Vagina	0 h	Se = 86.30%	Kronotech Srl, Campoformido, Italy https://www.oranasco.it/	Palombi et al. [12] Rossi et al. [13] Crociati et al. [22] Crociati et al. [14]
	Light	iVET®	167	Vagina	0 h	Se = 78%; Sp = 93%	iVET®-Geburtsüberwachung für Kühe https://www.nrw-agrar.de/projekt/piloterprobung-des-	Henningsen et al. [7]

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	Temperature	Gyuonkei	625	Vagina	0 h	n.a.	Remote Inc., Oita, Japan http://www.gyuonkei.jp/	Sakatani et al. [9]
[18]	Temperature	Vel'Phone®	211 241	Vagina	0 h	n.a.	Medria, Châteaugiron , France https://www.medria.fr/en/solutions/velphone/	Ricci et al. [10] Choukeir et al. [11]
			54	[19]	0 h	PPV = 100%		Horvàth et al. [8]

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se, thus ported to us cows time of gression on. This g, nor to decide when moving cows to the maternity pen. The purchase of this technology should be evaluated considering the possibility to re-use the device for multiple cows and the return of improved calving management. Moreover, in smaller herds, where the number of employees could not ensure continuous monitoring of periparturient cows, the presence of personnel within the calving barn is optimized and time spent monitoring animals is reduced. Specific employment in farms where the value of the calf is relevant (sorted semen, embryo transfer), can also benefit from these technologies. Timely calving assistance is beneficial for the overall farm reproductive and productive outcomes [19]. Palombi et al. [12] demonstrated that timely calving assistance and initial neonatal care reduce the incidence of postpartum uterine diseases such as retention of fetal membranes, metritis and neonatal mortality. Decreased incidence of uterine infections led both to reduced calving-conception interval and number of artificial inseminations per pregnancy in monitored dairy cows.

Ensuring colostrum intake during the first 6 h of life is fundamental for calf survival and welfare[20]; Morin et al. [21] found a positive association between adequate transfer of passive immunity and first colostrum feeding before 3 h of life. However, they also observed that only 42% of the newborn calves receive their first meal within this time interval and recommended farmers to improve calves and colostrum management. Therefore, increased workload for calving monitoring and newborn calf care could be perceived by farmers as time-consuming and expensive, but partial budget estimation of the effect of calving monitoring and assistance confirmed that a 100-lactating dairy herd could improve the net return from 37 to 90 €/cow/year. Those incomes resulted from reducing calf losses, involuntary culling during the first 60 days postpartum, and days open associated with an increased milk yield [22]. Consequently, investing in calf care could be paid back through the increased number of weaned calves for selling or replacement. On the other hand, exact identification of stage II of parturition could be beneficial in case early cow–calf separation and pathogen-free colostrum feeding is mandatory for the eradication of vertically transmitted diseases such as paratuberculosis and bovine leukemia virus [23][24].

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