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Moosense Pedometer for Oestrus Detection and Ovulation Time Prediction for Artificial Insemination in Karan Fries Cows

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ABSTRACT

Background: Improper estrus detection causes huge economic losses due to inaccurate time of insemination leading to poor conception rate. So, here pedometer proved to be a promising tool in defining optimal time of insemination,improving fertilization rates based on increased number of steps. The study is to determine the relationship between increased pedometer activity for efficient estrus alert and duration of estrus for prediction of accurate time of ovulation.

Methods: Oestrus detected in KF cows (N=20) by behavioural estrus visually. Further validated by pedometer activity and confirmed by progesterone (P4) and estradiol (E2) concentration. Individual animal daily activity pattern collected, transformed and arranged to in Excel sheet for statistical analysis for determining estrus alert, estrus duration, ovulation and insemination time.

Result: Based on pedometer estrus alert,duration, estrus onset and estrus end to ovulation was 15.63±1.46 h, 30.53±1.21 h and 14.89±2.03 h respectively. The mean activity count per hour (ACPH) for the pedometer oestrus (426.19±70.19) and E2 found associated on oestrus day. Based on oestrus alert and duration artificial insemination (A.I) can be made 10h after onset up to 5h after end of pedometer oestrus. Pedometer detects estrus slightly earlier than behavioural estrus efficiently and help in predicting the ovulation time for governing the accurate time of insemination.

Key words: Activity, Behaviour, Oestrus, Ovulation time, Pedometer.

INTRODUCTION

Effective reproductive management is the key to success in a dairy enterprise and efficient estrus detection is one of the primary determinants of a successful reproduction program. Huge economic losses are incurred due to incorrect and poor estrus detection in terms of extended calving intervals, milk loss, veterinary costs and an increase in the number of cows culled due to infertility (Walker *et al.,* 1996). Hence, estrus detection is a prerequisite for finding the right ovulation time and perform insemination at proper time (Sveberg *et al*., 2011) and therefore, accurate ovulation prediction is the major goal of a successful estrus-detection program (Stevenson *et al*., 2014).

Visual observation is a traditional method generally practiced for estrus detection. It can also be detected by body temperature change, mucus discharge, changes in vaginal mucus resistance and comprehensive knowledge of the characteristics of behavioural activities of farm animals including mounting activity and increase in a number of steps (Roelofs *et al.,* 2010). These behaviours of estrus are very good indicators of ovulation time. But the accuracy of detection is highly dependent on estrus intensity, observer's skill and observation frequency (Chanvallon *et al.,* 2014).

Estrus detection based on the increase in activity by pedometer is practiced since a long time from 1950's, it proved as a promising tool for estrus detection, (Firk *et al*., 2002) a prerequisite successful insemination. More accurate tool for determining oestrus than visual behaviour like mounting is recording onset and termination of walking activity (Silper *et al*., 2015). Mostly focus on pedometer is on estrus detection efficiency rather than enhancing fertilization rate. The fertilization possibility mainly depends on the interval from insemination to ovulation time (Roelofs *et al.,* 2005). Both too early and too late insemination is not congenial for fertilization. Since the onset of estrus is major determinant for deciding optimal time accurate estrus detection is very essential to improve the conception rate (Senger, 1994). Therefore, insemination time should be decided on ovulation time rather than simply on estrus detection. Moreover, if pedometer can predict ovulation time based on higher number of steps, the pedometer readings could be a device for improving fertilization rates. Therefore, the present study was designed to find the relationship between increase in number of steps measured by pedometer

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for efficient estrus alert, determining estrus duration, pre ovulatory surge and prediction of accurate time of ovulation for optimal time of Artificial Insemination (AI) in crossbred cattle.

MATERIALS AND METHODS

The present study was conducted on Karan Fries cows (HF × Tharparkar Cross) maintained at Livestock Research Centre of I.C.A.R-National Dairy Research Institute, Karnal, Haryana (India) for a period of 2017-2018. The Institutional Ethical Committee for Experimentation with Animals approved the experimental protocol.

Experimental animals and general management

A total of 20 lactating cows (parity 1-5, average daily milk yield 13.07 kg) housed in loose housing system under group management practice were selected randomly for study based on the behavioural signs and symptoms of estrus. All animals show regular signs of estrus having no reproductive problem. Behavior during each estrus episodes from each cow was recorded twice daily morning and evening visually for 30 minutes. Further estrus was confirmed by rectal examination, cervical mucus characteristics and hormone assay.

Moosense pedometer activity recording procedure

Wireless sensor network based precision animal management system known as Moosense was developed at ICAR-NDRI, Karnal (Sarangi *et al*., 2014). The experimental animals were 40-60 days in milk at the time of attaching moosense pedometer on fore leg of cows at the metatarsal region. The pedometer recorded the number of steps taken continuously 24 h and sends the activity on hourly basis to server through the site gateway for permanent storage up to 30 hrs for further analysis. Block diagram of pedometer system shown in Fig 1. Activity levels in animals increase drastically during oestrus when compared to baseline activities. Thus, pedometer are generating and providing useful valuable data for accurate oestrus detection to assist in insemination at the suitable time.

Calculation of change in number of steps (Pedometer oestrus) and ovulation time

Increase in number of steps (measured by a pedometer) was calculated to find pedometer oestrus using method based on the median number of steps (Roelofs *et al.,* 2005).

The ovulation time was determined in all cows that showed estrous behavior both by rectal palpation and by using linear array ultrasound scanner equipped with a multi frequency transducer probe (Prosound 2, Aloka Ltd., Japan). The animals detected in estrus by visual observation were examined per rectally guided by ultrasound every two-hour intervals to scan the ovarian follicle status to measure follicular diameter each time. Ovulation time was defined as the time when ultrasound preovulatory follicle disappeared minus1hr and determined for first time by ultrasound (Roelofs *et al.,* 2005). At end of estrus based on walking activity pedometer estrus alert, duration of estrus to ovulation was calculated.

Hormone assay

Blood was collected three days before oestrus and on oestrus day for estimation of estradiol (E2) and progesterone (P4) hormone. E2 was estimated to determine the peak level and P4 level estimated for confirmation of oestrus with level below <1 ng/ml. Blood collected at every 2h interval from the oestrus onset till ovulation for Luteinizing hormone (LH) estimation. After ovulation, blood was collected for two days at 24-hour interval. The hormone was estimated using ELISA test kit (Uscn Life Science Inc. Wuhan, Hubei) as per manufacturer's instruction. The standard concentration of E2 and P4 hormone was calculated using Graph Pad PRISMs 3.0 software (GraphPadSoftware, USA).

Statistical analysis

The activities of the animal during experiment was collected every day from individual animal for gathering information

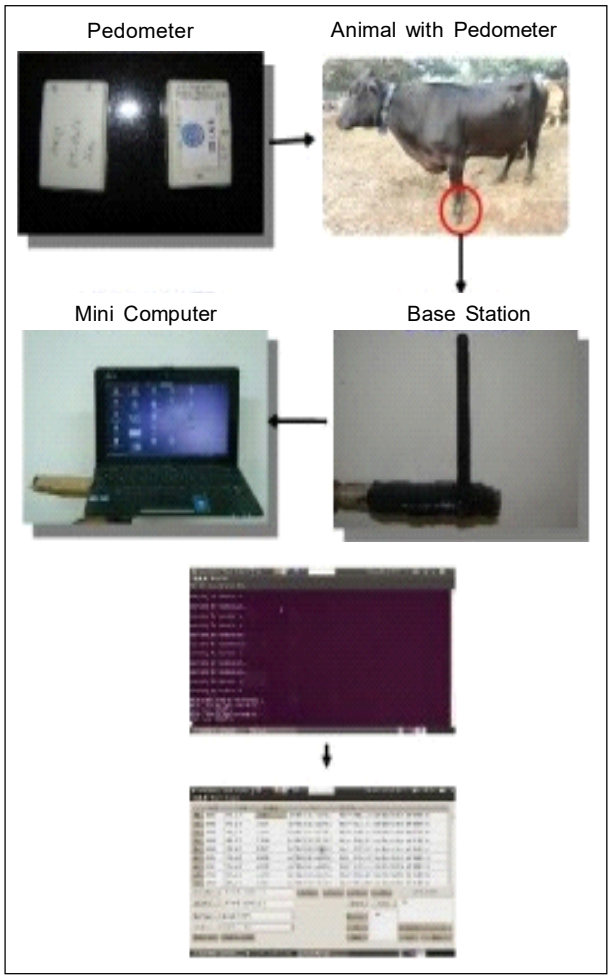


Fig 1: Block diagram of pedometer system. Moosense pedometer is attached to the cow s foreleg records the daily activity and transmits the data hourly to a PC over a wireless connection through base station and gets stored for further analysis.

about daily activity pattern analysis and was transformed to hourly activity in Excel sheet and arranged for statistical analysis. Descriptive analysis was conducted to find the mean, standard error and are presented as Mean±S.E by using SAS (9.4 Version).

RESULTS AND DISCUSSION

Relationship between increase in steps and time of ovulation

The ovulation time based on onset of oestrus and LH peak was recorded by rectal examination and by performing ultrasonography of the developing follicle. In present study, one out of 20 estruses was case of silent heat and did not show any behavioural symptoms but the pedometer was capable in heat detection, with lower total number of steps during estrus as compared to other estrus animals. This may be due to individual animal variation showing lesser activity. Mean duration of oestrus recorded by pedometer is 15.63±1.46 h (3-24 h). Duration of oestrus observed in the present experiment is comparable to the mean duration (13.4 h) reported for cows monitored for oestrus by visual observation of both primary (standing to be mounted) and multiple secondary signs of estrous behavior (Roelofs *et al.,* 2004). Similarly duration of oestrus activity for cows found to be 16.1±4.7 h (Accelerometer), 13.0±0.8 h (activity monitoring system) and 14.3±4.1 h (Heat time) and 15±4 h (Ice tag) respectively but findings here was higher than of Roelofs *et al*., (2005), Aungier *et al*., (2012) and Hojo *et al*., (2018). Discrepancies between duration of oestrus based on standing events or visual observation with that recorded based on activity are possibly due to the uncoupling of expression of secondary signs of oestrus behaviour and standing oestrus and this could be due to different device being utilized for estrus detection.

The mean duration from the oestrus onset and end to ovulation is depicted in Fig 2 which is reported to be 30.53±1.21 h (21-42 h) and 14.89±2.03 h (4-39 h) respectively sharing similarity with Roelofs *et al*., (2004, 2005, 2006) with mean duration of 29-30 h from oestrus to ovulation and 16.7 h from oestrus end to ovulation (Roelofs *et al.,* 2004) and slightly higher than our finding, *i.e*., 19.4 h (Roelofs *et al*., 2005). Additionally, similar result was seen by Valenza *et al*., (2012) using accelerometer oestrus detection system and Sood *et al*., (2014) by using a pedometer. In contrast oestrus to ovulation the mean duration from found to be shorter in the study of Stevenson *et al*. (2014), *i.e*., 25.7±0.4 h, however, the duration from the end of oestrus to ovulation was similar to our study (13.2 ±0.9 h). Variation in the oestrus-to-ovulation interval in lactating dairy cows could be explained by the difference in the onset of the oestrus-to-LH-surge interval. Indeed, in cows with a very long onset of oestrus to the LH surge found to have long oestrus-to-ovulation interval as compared with short duration from the onset of oestrus to the LH surge.

The mean duration from oestrus onset to LH peak and from LH peak to ovulation was 9.68±0.50 h and 20.84±1.25 h respectively in KF cows as depicted in Fig 3. LH peak and time of ovulation of various cows in estrus is depicted in Fig 4. From the figure it is clear that the most cows show LH surge 8-12 hrs after pedometer oestrus alert. This agreed with the finding (9.3 h) of Sood *et al*., (2014) but the finding Roelofs *et al*., (2004) for oestrus onset to LH peak duration lower than our study. The pedometer oestrus is within the normal range however, large variation observed in duration of pedometer oestrus between animals (3-24 h). In some animals the oestrus-LH peak is zero, indicating that the animals have come to heat earlier but pedometer is unable to detect that period. The results indicate that the increase in the number of steps preceding ovulation can be used to detect oestrus and to predict the time of ovulation fairly accurate.

Mean LH peak, P4 level and E2 concentration on oestrus day found to be 21.31±1.97 ng/ml (range 7.66-23.51 ng/ml), 0.47±0.04 ng/ml (range 0.29-0.54ng/ml) and 30.69±2.33 pg/ml (range 17.17- 43.17 pg/ml). In contrast the LH peak (9.3±0.6 ng/ml) and E2 (11±0.4 pg/ml) was lower but the level of P4 (1.62 ng/ml) was higher (Roelofs *et al.,* 2004). E2 concentration found to be lower (11.2±4.6 pg/ml) than Silper *et al*., (2015) during oestrus. Fig 5 indicates mean activity and E2 concentration (pg/ml) during oestrus in KF cows. The mean activity count per hour (ACPH) for the pedometer oestrus found to be 426.19±70.19 (range 171-875). Mean ACPH on estrus days reported to be 252.610±11.05

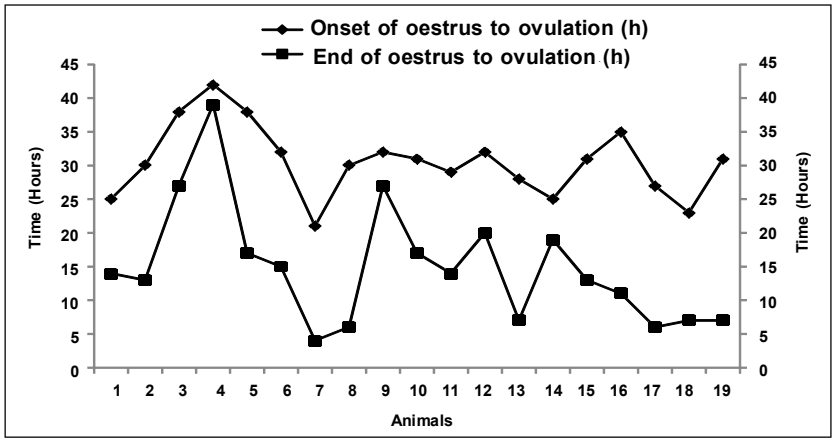


Fig 2: Onset and end of pedometer oestrus to ovulation duration (h) in KF cows.

activity/h (Madkar, 2013) and 371±91 when recorded with activity monitoring systems (Silper *et al.,* 2015) which was lower than present study. There is a relation between E2 concentration and activity on oestrus day, however huge variation seen in mean activity and E2 concentration. This difference may be due to individual variation and also may be due to an error in analyzing the sample. ACPH had positive correlation with E2 concentrations on day of oestrus (Kerketta *et al.,* 2019). Increase in activity could be an important secondary estrus behaviour for prediction of ovulation time based on efficient estrus detection. As 90-95% of the estrous periods mounting occurred during oestrus which acts as the best predictor for the time of ovulation (Roelofs *et al.,* 2004; 2005).

Pedometer oestrus profile at low and high ACPH

The total animals in estrus were grouped to low and high activity based on the mean ACPH recorded by pedometer estrus. Characteristics of pedometer oestrus and hormone profile at low and high ACPH is presented in Table 1. The total

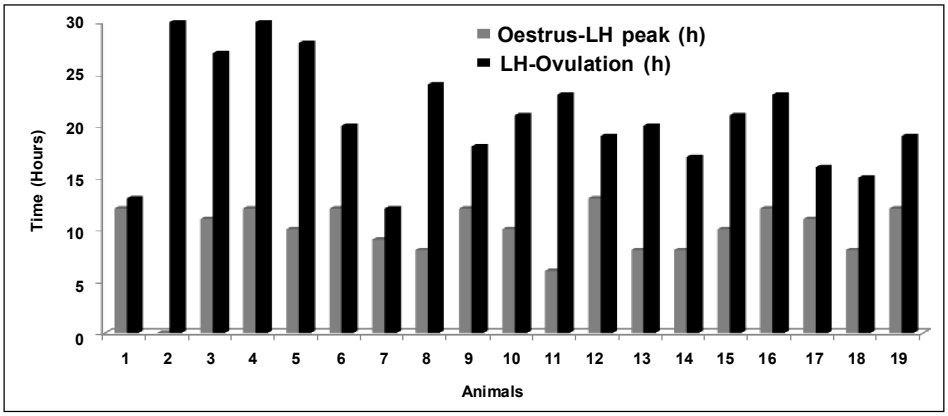


Fig 3: Onset of estrus to LH peak and LH peak to ovulation duration (h) measured by pedometer (h) in KF cows.

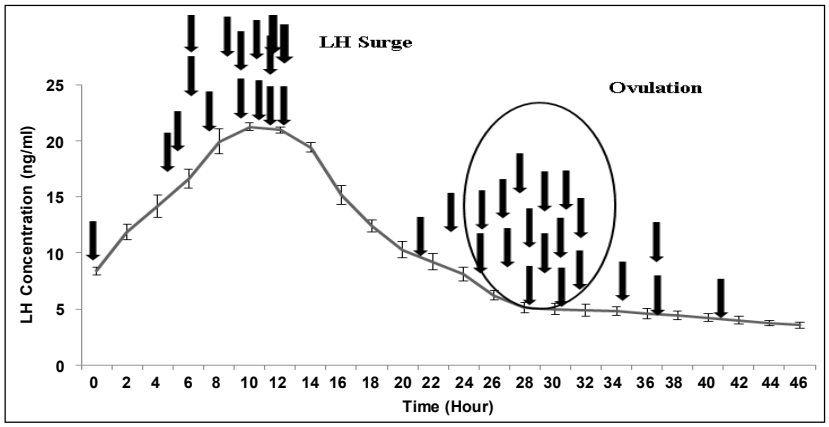


Fig 4: LH peak and ovulation time in KF cows.

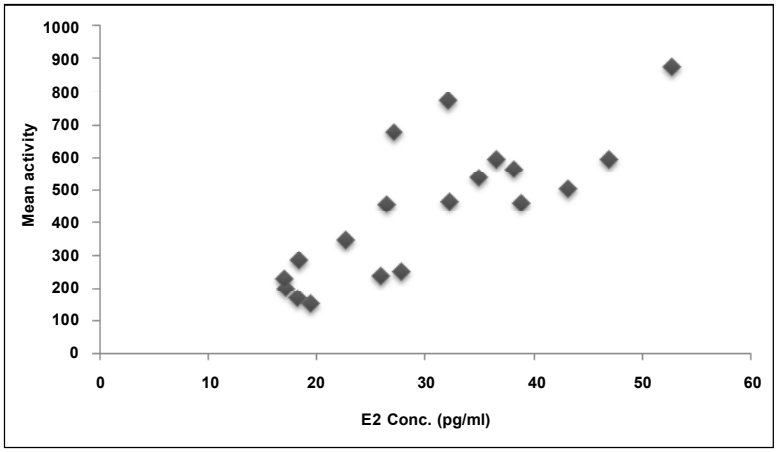


Fig 5: Activity count per hour (ACPH) and estradiol concentration (pg/ml) during Oestrus in KF cows.

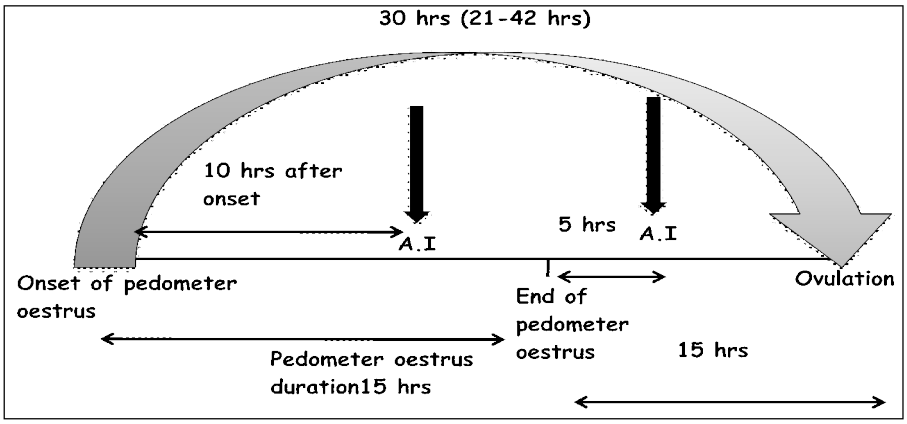


Fig 6: Timing of insemination proposed by Moosense Pedometer by Pedometer oestrus Alert.

Table 1: Characteristics of pedometer oestrus and hormone profile at low and high ACPH (Mean±SE).

	Activity	
	Low	High
Total duration (h)	14.22±2.16	16.90±1.90
Start of oestrus to ovulation duration (h)	32.44±1.85[a]	28.80±1.35[b]
End of oestrus to ovulation duration (h)	18.22±3.16[a]	11.90±2.18[b]
Oestrus-LH peak duration (h)	4.33±0.77	3.60±0.65
LH-Ovulation duration (h)	28.11±1.81	25.20±1.62
LH Peak (ng/ml)	19.93±2.77	20.26±2.82
P4 conc. (ng/ml)	0.46±0.07	0.47±0.07
E2 (pg/ml)	29.53±3.22[a]	33.10±3.31[b]

Different superscript (a and b) within row differ significantly (P<0.05).

duration of oestrus was longer for high activity animals (16.90 hrs vs. 14.22 hrs). Because of longer oestrus the duration from oestrus onset to ovulation and oestrus end to ovulation was significantly (p<0.05) shorter (28.80 h vs. 32.44 h) in high activity animals than low (11.90 h vs. 18.22 h) activity animals.

Oestrus to LH peak and LH surge to ovulation duration found longer in low activity animals. Further mean LH Peak and P4 found to be higher than low activity animals. E2 concentration is significantly (p<0.05) higher in high activity in comparison to low activity animals. Thus it is very clear that in high activity animals mean total estrogen concentration during the perioestrus period was significantly correlated with oestrus behavior (Mondal *et al.,* 2006) and estradiol reaches its highest level at the same time as the maximum behavior score (Lyimo *et al.,* 2000; Galina *et al.*, 2007). So here the oestrus behaviour like pedometer activity and oestrus duration is high having higher E2 concentration and P4 less than <1 ng/ml.

Pedometer estrus alert and timing of insemination

The insemination timing proposed by Moosense pedometer on the basis of pedometer oestrus alert is depicted in Fig 6. The duration of oestrus detected by pedometer is slightly earlier than the oestrus normally observed by standing to be mounted as it gives 3-4 hr before visual oestrus alert so the best time of A.I based on pedometer oestrus alert and duration can be done 10 hrs after onset up to 5 hrs after end of pedometer oestrus to cover all animals having ovulation at different window as the highest conception rates for AI occurred between 4 and 12 hr after onset of standing activity (Dransfield *et al.,* 1998). Similarly duration of behavioral oestrus was on average 2hr longer (11.8 hr) compared to pedometer oestrus (10.0 hr) (Roelofs *et al.,* 2005). A.I done at 15.5 hr and 14.4 hr based on standing heat and silent heat measured by radiotelemetric pedometer with conception rate of 57.1% and 60% respectively (Hojo *et al.,* 2018). Further, conception rate was more (90% vs. 58%) when A.I done 10-18 hrs after an increase in pedometer activity compared to A.M-P.M rule (Yoshioka *et al.*, 2010).

CONCLUSION

Moosense pedometer detects oestrus in animals slightly earlier than normal estrus behaviour. Estrus detection based on this device is very efficient and proved to be a promising tool for predicting the time of ovulation for governing the accurate time of insemination. However only threshold is needed to be decided for a pedometer for detection of estrus in different farm condition.

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REFERENCES

Aungier, S.P.M., Roche, J.F., Sheehy, M. and Crowe, M.A. (2012). Effects of management and health on the use of activity monitoring for estrus detection in dairy cows. J. Dairy Sci. 95: 2452-2466.

Chanvallon, A., Coyral-Castel, S., Gatien, J., Lamy, J.M., Ribaud, D., Allain, C., Clément, P. and Salvetti, P. (2014). Comparison of three devices for the automated detection of estrus in dairy cows. Theriogenology. 82: 734-741.

Coe, B.L. and Allrich, R.D. (1989). Relationship between endogenous estradiol-17beta and estrous behaviour in heifers. J. Anim. Sci. 67: 1546-1551.

Dransfield, M.B.G., Nebel, R.L., Pearson, R.E. and Warnick, L.D. (1998). Timing of insemination for dairy cows identified in estrus by a radiotelemetric estrus detection system. J. Dairy Sci. 81: 1874-1882.

Firk, R., Stamer, E., Junge, Wand Krieter, J. (2002). Automation of oestrus detection in dairy cows: A review. Livest. Prod. Sci. 75: 219-232.

Galina, C.S. and Orihuela, A. (2007). The detection of the estrus in cattle raised under tropical conditions: What we know and what we need to know. Horm. Behav. 52: 32-38.

Hojo, T., Sakatani, M. and Takenouchi, N. (2018). Efficiency of a pedometer device for detecting estrus in standing heat and silent heat in Japanese Black cattle. Anim. Sci. J. 89: 1067-1072.

Kerketta, S., Mohanty, T.K., Bhakat, M.,Kumaresan, A., Baithalu, R., Gupta, R., Mohanty, A.K., Abdullah, M., Kar, S., Rao, V. and Fahim, A. (2019). Moosense pedometer activity and periestrual hormone profile in relation to oestrus in crossbred cattle. Indian J. Animal Sci. 89(12): 1338-1344.

Lyimo, Z.C., Nielen, M., Ouweltjes, W., Kruip, T.A. and Van Eerdenburg, F.J. (2000). Relationship among estradiol, cortisol and intensity of estrous behaviour in dairy cattle. Theriogenology. 53(9): 1783-1795.

Madkar, A. (2013). Efficiency of wireless sensor device (Pedometer) for detection of estrus in Karan Fries cows. M.V.Sc. Thesis submitted to N.D.R.I, Karnal.

Mohanty, T.K., Ruhil, A.P., Kar, S., Lathwal, S.S., Behera, K., Layek, S.S., Pathbandha, T. and Sarangi, S. (2010). Climate Control of Livestock Houses Through Sensor Controlled System. In: Int. Conf. Physio. Capacity Building in Livest. under Chang. Clim. Scenario, Bareilly (1). PP: 48-53.

Mondal, M., Rajkhowa, C. and Prakash, B.S. (2006). Relationship of plasma estradiol-17β, total estrogen and progesterone to estrus behaviour in mithun (*Bos frontalis*) cows. Horm. Behav. 49: 626-633.

Peter, A.T. and Bosu, W.T. (1986). Postpartum ovarian activity in dairy cows: Correlation between behavioral estrus, pedometer measurements and ovulations. Theriogenology. 26(1): 111-115.

Roelofs, J., Lopez-gatius, F., Hunter, R.H., van Eerdenburg, F.J. and Hanzen, C. (2010). When is a cow in estrus? Clinical and practical aspects. Theriogenology. 74: 327-344.

Roelofs, J.B., Bouwman, E.G., Dieleman, S.J., Van Eerdenburg, F.J., Kaal-Lansbergen, L.M., Soede, N.M. and Kemp, B. (2004). Influence of repeated rectal ultrasound examinations on hormone profiles and behaviouraroundoestrus and ovulation in dairy cattle. Theriogenology. 62(7): 1337-1352.

Roelofs, J.B., Graat, E.A.M., Mullaart, E., Soede, N.M., Voskamp-Harkema, W. and Kemp, B. (2006). Effect of time of insemination relative to ovulation on fertilization rates and embryo characteristics in spontaneous dairy cattle. Theriogenology. 66: 2173-2181.

Roelofs, J.B., Van Eerdenburg, F.J.C.M., Soede, N.M. and Kemp, B. (2005). Pedometer readings for estrous detection and as predictor for time of ovulation in dairy cattle. Theriogenology. 64: 1690-1703.

Roelofs, J.B., van Eerdenburg, F.J.C.M., Soede, N.M. and Kemp, B. (2005). Various behavioural signs of estrus and their relationship with time of ovulation in dairy cattle. Theriogenology. 63: 1366-1377.

Saacke, R.G., Dalton, J.C., Nadir, S., Nebel, R.L. and Bame, J.H. (2000). Relationship of seminal traits and insemination time to fertilization rate and embryo quality. Anim. Reprod. Sci. 60-61: 663-677.

Sarangi, S., Bisht, Rao, A., Kar, S., T.K, Mohanty. and Ruhil, A.P. (2014). Development of a Wireless Sensor Network for Animal Management: Experiences with Moosense. IEEE International Conference on Advanced Networks and Telecommuncations Systems (ANTS), New Delhi, 2153-1676. PP: 1-6.

Senger, P.L. (1994). The estrus detection problem: New concepts, technologies and possibilities. J. Dairy Sci. 77: 2745-2753.

Silper, B.F., Madureira, A.M.L., Kaur, M., Burnett, T.A. and Cerri, R.L.A. (2015). Short communication: Comparison of estrus characteristics in Holstein heifers by 2 activity monitoring systems. J. Dairy Sci. 98: 3158-3165.

Sood, P., Vasishta, N.K., Singh, M.and Pathania, N. (2009). Prevalence and certain characteristics of mid-cyclic estrus in crossbred cows. Vet. Arch. 79: 143-149.

Stevenson, J.S., Hill, S.L., Nebel, R.L. and DeJarnette, J.M. (2014). Ovulation timing and conception risk after automated activity monitoring in lactating dairy cows. J. Dairy Sci. 97: 4296-4308.

Sveberg, G., Resdal, A.O., Erhard, H.W., Kommisrud, E., Aldrin, M., Tvete, I.F., Buckley, F., Waldmann, A. and Ropstad, E. (2011). Behaviour of lactating Holstein-Friesian cows during spontaneous cycles of estrus. J. Dairy Sci. 94: 1289-1301.

Valenza, A., Giordano, J.O., Lopes, G., Vincenti, L., Amundson, M.C. and Fricke, P.M. (2012). Assessment of an accelerometer system for detection of estrus and treatment with gona--dotropin-releasing hormone at the time of insemination in lactating dairy cows. J. Dairy Sci. 95: 7115-7127.

Walker, W.L., Nebel, R.L.and McGilliard, M.L. (1996). Time of ovulation relative to mounting activity in dairy cattle. J. Dairy Sci. 79(9): 1555-1561.

Yoshioka, H., Ito, M. and Tanimoto, Y. (2010). Effectiveness of a real-time radiotelemetric pedometer for estrus detection and insemination in Japanese Black cows. J. Reprod. Dev. 56: 351-355.