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The Use of Pedometry for Estrus Detection in Dairy Cows in Israel

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Abstract. The objectives of this review are to describe the use of pedometry on commercial dairy farms in Israel, to evaluate its efficiency in heat detection and to describe a clinical trial comparing between pedometry and the Ovsynch technique. Pedometry is the major tool of heat detection on most farms in Israel today. On many farms automated electronic pedometry is the sole mean of heat detection. Production and reproduction parameters are monitored by Hachaklait Veterinary Services Ltd. Results are compared with the farm history and with national means and goals. The average herd rate of undetected heat in more than 120 herds recorded between 2004 and 2008 has increased from 30.3 to 38.9% in primiparous cows and from 33.9 to 43.9% in multiparous cows respectively. The average duration of the waiting period has dropped from 106.2 to 93.4 days and from 99.9 to 87.3 days in primiparous and multiparous cows respectively. The average annual rate of cows shown on heat by pedometry and not inseminated by the A.I. technicians in recent years was 13% and remained steady. The mean herd rate of normal length heat cycles (18–24 days) in multiparous cows in recent years has been fairly steady; 57.4 to 58.4% of all cycles detected in 2004 and 2008 respectively. Herd rate of double cycles is also used to estimate the sensitivity of pedometry systems. Average rate of double cycles (37–60 days) per herd per annum in multiparous cows has dropped steadily from 22.6 to 20.1% between 2004 and 2008 respectively. Mean herd rate of short cycles in multiparous cows in 2008 was 7.4% Pregnancy checks are performed by the herds' veterinarians by transrectal palpation from 40 days post A.I. onward. In 2008 the average herd rate of negative pregnancy checks in cows was 27.5% (9.5–53.4%). The wide range indicates a large variability of pedometry system in tracking non-conceived cycling cows. Beside activity and heat detection pedometry systems record other individual cow parameters. A controlled field trial comparing between pedometry, observation and Ovsynch did not yield significant differences in reproductive measures.

Key words: Conception rate, Heat detection, Ovsynch, Pedometry

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Pedometry has been used for heat detection in the last several decades in many countries with variable intensity[1]. Motion meters known as pedometers are placed on the hind leg, front leg or on the neck of the cow and monitor cow movements. Several studies were published on their use, their accuracy, their efficiency in heat detection and their effect on reproductive management [1–8]. The first pedometry system in Israel was installed in Kibbutz Afikim in 1986 and since then has been increasingly used on many farms. Today it is the major tool of heat detection in most farms. Currently pedometry system are used in all of the 165 large Kibbutz (250–900 milking cows) dairy farms and in about half of the smaller family farms (ranging from 40 to 200 milking cows). Almost all the pedometry systems used in Israel are of local brands. The majority of farms use Afimilk® with pedometry meters placed on the leg, and the minority use SCR Engineers LTD with meters placed on the neck. Both systems incorporate other gadgets and monitor various other parameters.

Heifers and cows in Israel are housed mostly in loose barns with no access to pasture. Few herds have few free stalls barns, and none use tie stalls barns. In recent years routine systematic heat observation by farm workers has been reduced, and on many farms automated electronic pedometry is the sole mean of heat detection. On some farms random observation is still used as a complementary mean to pedometry. The shift from observation to pedometry is being explained by the increasing cost of labor and the high efficiency of pedometry. Herd hormonal synchronization programs such as "Ovsynch" and its variations are not widely practiced in Israel as a reproductive strategy. Hormonal therapy is limited only to undetected cows at the end of the voluntary waiting period. A few field studies in Israel that compared between Ovsynch and pedometry did not find significant differences. Over the years only a few controlled studies were done in commercial farms to evaluate the efficiency of pedometry and large part of the data is supplied by the commercial suppliers.

Hachaklait Veterinary Services Ltd has an epidemiology department which continuously monitor and analyzes detailed and reliable herd data from hundreds of dairy herds. Among other production and reproduction parameters we monitor and evaluate the efficiency of heat detection. Each herd results are compared with farm history, national means and goals.

Pedometer System Description

A pedometer system includes the following components:

a. Pedometer tag which is mounted by a strap around a cow's leg. It is used to identify the cow in the milking parlor. In addition to the identification (ID) number of the tag, data recorded on a tag includes the number of steps done by the tagged animal; cow, sheep or goat.
b. Antenna(s) reading the animal ID and step count accumulated by the pedometer.
c. An identification unit that interfaces between the sensor

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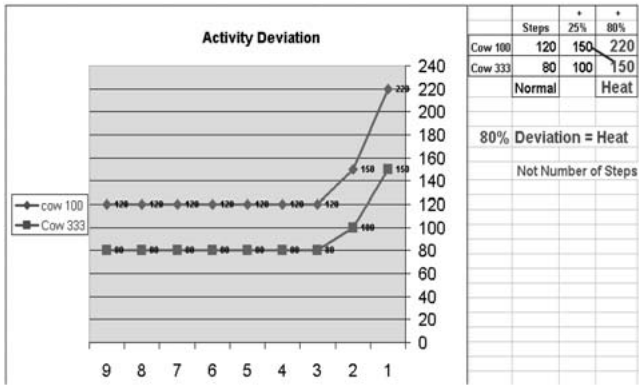
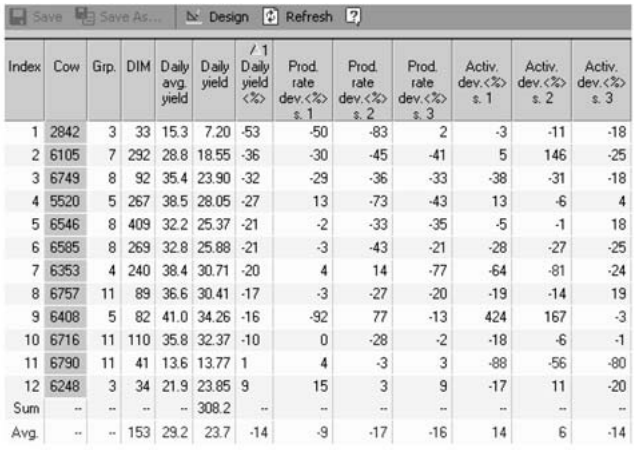


Fig. 1. Activity graph of two cows showing individual deviation (Afimilk®).



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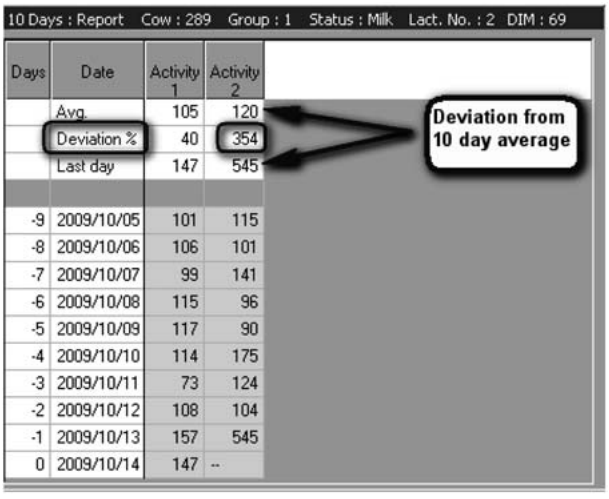
Index	Cow	Grp.	DIM	Daily avg. yield	Daily yield	/ 1 Daily yield <%>	Prod. rate dev.<%> s. 1	Prod. rate dev.<%> s. 2	Prod. rate dev.<%> s. 3	Activ. dev.<%> s. 1	Activ. dev.<%> s. 2	Activ. dev.<%> s. 3
1	2842	3	33	15.3	7.20	-53	-50	-83	2	-3	-11	-18
2	6105	7	292	28.8	18.55	-36	-30	-45	-41	5	146	-25
3	6749	8	92	35.4	23.90	-32	-29	-36	-33	-38	-31	-18
4	5520	5	267	38.5	28.05	-27	13	-73	-43	13	-6	4
5	6546	8	409	32.2	25.37	-21	-2	-33	-35	-5	-1	18
6	6585	8	269	32.8	25.88	-21	-3	-43	-21	-28	-27	-25
7	6353	4	240	38.4	30.71	-20	4	14	-77	-64	-81	-24
8	6757	11	89	36.6	30.41	-17	-3	-27	-20	-19	-14	19
9	6408	5	82	41.0	34.26	-16	-92	77	-13	424	167	-3
10	6716	11	110	35.8	32.37	-10	0	-28	-2	-18	-6	-1
11	6790	11	41	13.6	13.77	1	4	-3	3	-88	-56	-80
12	6248	3	34	21.9	23.85	9	15	3	9	-17	11	-20
Sum	--	--	--	--	308.2	--	--	--	--	--	--	--
Avg.	--	--	153	29.2	23.7	-14	-9	-17	-16	14	6	-14

Fig. 3. Milk yield and activity of several cows in one herd. Afimilk®.



10 Days : Report Cow : 289 Group : 1 Status : Milk Lact. No. : 2 DIM : 69

Days	Date	Activity 1	Activity 2
	Avg.	105	120
	Deviation %	40	354
	Last day	147	545
-9	2009/10/05	101	115
-8	2009/10/06	106	101
-7	2009/10/07	99	141
-6	2009/10/08	115	96
-5	2009/10/09	117	90
-4	2009/10/10	114	175
-3	2009/10/11	73	124
-2	2009/10/12	108	104
-1	2009/10/13	157	545
0	2009/10/14	147	--

Deviation from 10 day average

Fig. 2. Activity data of a single cow in a table for. Afimilk®.

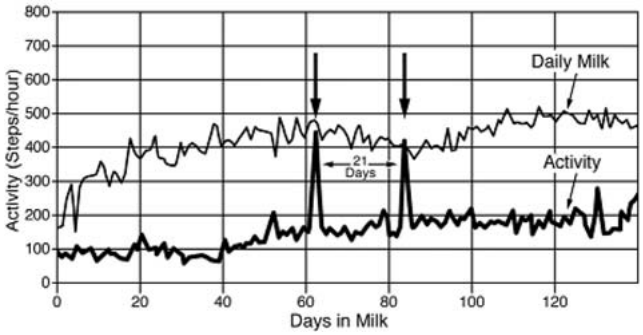


Fig. 4. Lactation activity and milk production curve (Afimilk).

(Antenna) and the software on the farm computer (PC).

The main functions of the pedometer unit are: 1. Receiving an identification request from the computer. 2. Sending power and frequency signals to activate the antenna. 3. Receiving the identification response from the cow tag. 4. Translating the analog data to a digital sequence and sending the identification data to the computer. 5. Personal computer (PC) with special software to record animal ID and activity data. The software is used to create reports on the activity of each cow over previous time periods. Cows usually show increased activity prior to the onset of standing heat by a factor of two to four folds of their individual normal (average) steps count. Cows should be considered ready for insemination within 12–24 h after being identified with increased activity by the pedometer system.

The pedometer serves two purposes; cow identification and activity measuring. It has an active step counter component, including an internal battery. The steps counter is activated by the walking activity of the animal. The data is stored and transmitted when the animal is identified. This generally occurs at set milking times during the day (twice, three times or more) or at a "bottle neck" such as a gate to the feed bunk in the case of pre milking heifers.

Each 24 hour period is divided into two to five time sessions. Steps per hour for the most recent time session (period) are compared to the mean value of the preceding 10 days during the reference period (same time period). A deviation from the last 10 day average for any time session will send the animal automatically to an "Estrus Attention list" (Fig. 1–3) and in a graphic form (Fig. 4). There are default thresholds of deviations supplied by the pedometry system dealer, but each user can and does modify these parameter settings according to the specific situation on a specific farm, or even at a level of a specific barn within the farm. Pedometry system adjustments should be done at the farm level according to the specific farm conditions; size, number of milking per day, type of barns, walking distance from barn to parlor and other activities occurring on the farm.

Table 1. Results of undetected heat rate in primiparous and multiparous cows in Kibbutz herds in Israel over five years period

primiparaous cows								
year	n	mean	SD	min	25% tile	median	75% tile	max
2008	149	38.9	15.2	10.4	27.5	38.0	48.4	92.2
2007	146	37.5	15.9	10.1	26.0	35.9	43.5	94.6
2006	130	34.7	12.7	10.4	26.6	32.2	42.4	81.0
2005	128	31.3	12.0	10.0	23.2	29.3	37.8	88.4
2004	123	30.3	12.3	10.2	21.9	28.3	36.7	71.7
maltiparaous cows								
year	n	mean	SD	min	25% tile	median	75% tile	max
2008	149	43.9	13.6	13.4	34.9	41.6	50.4	91.0
2007	146	42.5	15.6	16.7	31.0	41.0	49.5	96.6
2006	130	29.2	12.2	12.6	31.3	38.3	45.4	80.9
2005	128	33.7	11.9	10.9	25.8	30.1	39.8	77.5
2004	123	33.9	11.5	10.0	25.5	33.1	41.2	68.8

n= number of herds, min=lowest, max=highest, 25%=lower quartile and 75% higher quartile.

Table 2. Distribution of estrous cycle length in primiparous and multiparous cows in 145 (n) kibbutz herds in Israel in 2008

Cycles destribution—multiparaous cows (2008)								
Class	n	mean	SD	min	25%tile	median	75%tile	max
Short	145	7.4	3.3	0.0	5.0	7.0	9.0	19.0
Medium	145	58.4	5.7	35.0	55.5	59.0	62.0	73.0
Long	145	14.2	3.2	7.0	12.0	14.0	16.0	28.0
Double	145	20.1	4.7	9.0	18.0	20.0	22.0	40.0
Cycles distribution—primiparous cows (2008)								
Class	n	mean	SD	min	25%tile	median	75%tile	max
Short	145	5.1	3.1	0.0	3.0	5.0	7.0	17.0
Medium	145	62.8	7.2	36.0	58.0	63.0	68.0	81.0
Long	145	11.7	3.9	3.0	9.0	11.0	14.0	32.0
Double	145	20.5	5.2	7.0	17.0	20.0	23.5	37.0

Length classes: short (5–17 days), medium or normal (18–24 days), long (25–36 days) and double (37–60 days).

Results of Parameters Related to Pedometry from Israeli Dairy Farms

The average herd rate of undetected heat in more than 120 herds recorded between 2004 and 2008 has increased respectively from 30.3% (ranging from 10.2–71.7%) to 38.9% (10.4–92.2%) in primiparous cows and from 33.9% (10.0–68.8%) to 43.9% (13.4–91.0%) in multiparous cows (Table 1). Some of these cows are cyclic cows that were not detected by the pedometry systems. At the same period of time the average duration of waiting period (days from calving to first insemination) has dropped from 106.2 to 93.4 days and from 99.9 to 87.3 days in primiparous and multiparous cows respectively. Shortening of the waiting period, by half of a normal cycle, leaves less time for heat detection by pedometry. The average annual rate of cows shown on heat by the pedometry system and that have not been inseminated by the A.I. technicians was 13% and remained steady in the last several years. The main A.I. refusal reasons as recorded by these AI technicians were; lack of uterine tonus and unclear (murky or puss containing) vaginal discharge.

The recorded heat cycles in each herd are divided according to their length into four categories: short (5–17 days), medium or normal (18–24 days), long (25–36 days) and double (37–60 days). Data from more than 130 herds with at least 150 milking cows per farm are monitored routinely by Hachaklait. The mean herd rate of normal length cycles (18–24 days) in multiparous cows in recent years remained fairly steady; 57.4% (±5.7, 44–71%) to 58.4% (±5.4, 35–73%) of all cycles detected in 2004 and 2008 respectively. The wide range around herd average is attributed more to pedometry system fine tuning and human interpretation of the activity data rather than to the changes in cows' heat expression. Herd rate of double cycles may also be used to estimate the sensi-

tivity of pedometry systems. The average rate of double cycles (37–60 days) per herd per annum in multiparous cows has dropped steadily from 22.6% (±4.7, 12.0–37.0) to 20.1% (±4.7, 9.0–40.0) between 2004 and 2008 respectively. Pedometry in herds with high rate of double cycles is suspected to be sub-sensitive due to setting a too high threshold, or overlooking cows' activity peaks. Herds with high rates of short cycles (5–17 days) are suspected for having cystic ovarian disease or pedometry setting with a too low trigger value. The mean rate of multiparous cows with short cycles in a herd was 6.3% (±3.3, 1.0–15.0) in 2004 and 7.4% (± 3.3, 0.0 – 19%) in 2008.

Pregnancy diagnosis is performed on most farms in Israel by the herds' veterinarians by transrectal palpation from 40 days post A.I. onward. The rate of non-pregnant cows detected can also be used to evaluate the sensitivity of the pedometry system. In 2008 the average herd rate of negative pregnancy checks was 13.2% (±6.1, 5.6–38.5) in heifers and 27.5% (±7.7, 9.5–53.4%) in cows.

Comparison between the "Ovsynch" method and Pedometry in Israel

Ovsynch (an abbreviation for ovulation synchronization) is used widely in the United States of America and to various extents in other countries. Ovsynch is considered as a highly effective method for improving reproductive performance. The technique was developed by Pursley *et al.* in 1995 in the USA. The Ovsynch method uses well-known hormones: GnRH and Prostaglandin (PG). The hormones are injected in a fixed order and dosages protocol followed by timed artificial insemination (TAI) on the tenth day. Ovsynch induces ovulation rather than estrus and is often performed on a large number of dairy or beef cows together.

The aim of this trial was to evaluate the efficiency of Ovsynch versus the methods currently used by the large Israeli dairies; pedometry and heat observations. The trial was performed during the Israeli hot and humid summer.

Materials and Methods

A controlled clinical field study was conducted on two Kibbutz dairy farms in the northwestern part of Israel during the summer months of the 2000. Both farms had about 300 milking cows, which were milked three times a day with an annual production of over 11,000 kg per cow in 305-day lactation. The average summer mid day temperature is 30 C and the air humidity is around 80%. Seventy Israeli Holstein cows were assigned to a trial group and were paired with 70 cows in a control group. The cows were sorted into groups according to parity, calving month of the year and the presence post partum uterine diseases (placenta retention and or endometritis).

The treatment protocol of the trial group cows was the following: On the first day (day zero), which could be any day of the estrus cycle, an intramuscular (IM) injection of a synthetic analogue of GnRH equivalent to 100 μg, followed by an IM injection of 500 μg Cloprostenol (2 ml of Estrumate®) seven days later. Forty-eight h later, a second IM injection of 100 μg of GnRH was given. AI was performed on the following day (16–24 h after the last injection). The same AI technicians come to each farm at a fixed time every day. The AI technician inseminates only cows which he finds suitable for insemination out of the cows presented to him by the farm workers. The AI technicians were not aware of the trial performed (a blind trial). For convenience of management the Ovsynch treatments were grouped into treatment blocks that started every 14 days for a group of cows that past the elective waiting period. Milk from the Ovsynch cows was sampled for progesterone level, at the morning milking of day 10 before being presented for service. The control group cows were observed for heat twice a day for 45 min on dairy A, while on farm B the control cows were detected for heat only by the pedometry system (Afimilk®) and were inseminated by the same AI technician.

Results

Sixty-nine and 66 cows completed the Ovsynch protocol in the treatment and in the control groups respectively. Insemination rate of first service, at the end of the procedure on farm A, was 89% in the Ovsynch group and 90% in the control group. On farm B, service rate was 97% and 86% for the Ovsynch and for the control group respectively. Conception Rate at 1st service on farm A was 28.6% (10 out of 35) in the Ovsynch group and 25.7% (9 out of 35) in the control group. On farm B, 6 out of 34 (17.6%) and 7 out of 31 (22.6%) in the Ovsynch and in the control groups were found pregnant from 1st service respectively. The average number of rest days (days from calving to first AI) of both farms together was 80 and 81, and the average number of days open was 117 and 120 for the Ovsynch and for the control groups respectively. None of the differences were statistically significant. Progesterone level in milk of less than 1 ng/ml is considered as an indicator of standing heat and ovulation.[10] Progesterone level of less than 1 nm/ml in milk on the 10th day of the Ovsynch protocol was measured in 29 out of the 31 cows (94%) in farm A, and in 24 out of 26 cows (92%) in farm B. Out of these 26 cows with low progesterone which were inseminated on farm B, only 14 (54%) were detected by the pedometry system ("silent heat") which is a known phenomenon of the Ovsynch protocol.

Conclusions of the Ovsynch trial

The Ovsynch protocol was found in this study to be highly effective in bringing cows to ovulate with or without heat signs. Conception rate at 1st service in the treated cows was not higher in the Ovsynch cows compared with the heat-detected cows or the heat observed cows of the control groups. The rest period and the days open were also similar in both groups. Using Ovsynch did not raise the low summer fertility, yet showed that ovulation can be achieved, and possibly fortifies the hypothesis that the fertility problem during the summer months is more in the maintenance of the early embryo at the beginning of pregnancy, rather than achieving of ovulation and conception.

The advantages of Ovsynch are: a. There is no need to detect heat by observation, by pedometry, or by rectal palpation. b. The technique can be used on all farm sizes, especially those that find pedometry systems to be too costly. c. Ovsynch can be used constantly or only seasonally and it can be used to induce ovulation either in an individual cow or to synchronize a group of cows. d. Large proportion of heats is silent and so preventing or minimizing

physical trauma, mastitis and other heat related losses. e. AI is performed automatically without speculating when is the right time, as is done using prostaglandin synchronizations. f. Ovsynch can also be used to treat cows with cystic ovaries.

The main disadvantages are: a. Cost of the hormones is high, (4–5€ per cow) and the price per pregnancy is even greater in high producing herds with 1st conception rate of about 40%. b. Ovsynch requires more work because of the need for fetching and tying cows up in locks in an loose-barn farms. c. Ovsynch should be used only in well-managed, good record keeping, well-fed herds and, will not bring about "miracles" in poorly managed farms. d. In recent years in some developed countries the wide use of hormones in healthy cows draws an increasing objection on the ground of consumers' health and unnecessary interference with a "natural" food.

Many modifications to Ovsynch were developed (Co-Synch, Heat-Synch, Pre-Synch, Half-Synch etc.) in order to adapt and adjust to varying conditions with large variation in results.

Over All Conclusions and Discussion

Pedometry systems are widely used in Israel with various results. In Israel most of the barns are open space with 20 m2 or more per cow. Cows can move around freely and express estrous behavior. In free stalls or tie stalls barns the limited space reduces the ability of pedometry system to detect heat. The wide range of results in reproductive parameters described above indicates a large variability of the pedometry systems in tracking cycling cows. Pedometry system adjustment should be done at the farm level according to specific farm conditions; size, number of milking per day, walking distance from barn to parlor and other activities. The basic training of new users and continuous support of farm personnel are important to maximize the benefits of the pedometry system. The human skill and experience to differentiate a "true" peak of activity caused by estrous behavior from a "false" peak in activity due to other causes for an increase in the number of steps recorded are closely related to a better reproductive management. Beside activity and heat detection the present versions of pedometry systems can also monitor and record other parameters: Individual cow milk yield, milk electrical conductivity, milk components such as fat, protein and lactose contents, SCC, walk-over weight scale, sorting gate, periods of rest (Pedo-Plus, Afimilk®) and rate of rumination (SCR). Not only increase in activity but also reduced activity combined with other detected parameters can be used, especially to identify sick cows. Some of these parameters are used as indices of animal welfare. These added values make such systems a comprehensive and efficient management tool of a modern dairy farm; they improve their cost-benefit ratio and reduce their payback time. According to the manufacturing companies data the payback time of a pedometry system is 1-3 years, depending on farm size and the extra components included. With the growing public interest in the living conditions of food producing animals, and the growing objection to any unnecessary use of pharmaceuticals including reproductive hormones, pedometry systems as well as other technologies are a useful tool and substitute. Veterinarians should learn to use these technologies, incorporate them into their routine and diagnostic work on the farm, to the benefit of the animals, the farmer and food safety and quality.

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