# New Technology for Managing Heat Detection

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## Introduction

Estrous detection is the single most limiting factor in optimizing reproductive efficiency in dairy herds utilizing artificial insemination. It is generally agreed that heat detection efficiency is ≤50% in most dairy herds,[1,2,3] with the average for herds on DHIA from Dairy Records Processing Center in Raleigh, North Carolina, averaging 43%.[4] This does not however, take into account the accuracy of heat detection. Using milk and blood progesterone assays, research indicates that between 5 and 30% of all inseminations are performed when cows are not in estrus.[5] In fact, this author has previously worked with a herd in which 43% of all cows submitted for artificial insemination in a 30 day period of time had progesterone levels indicative of diestrus.

With labor being the second largest expense of the dairy behind feed cost, the amount of time spent for labor force in heat detection can save producers a significant portion of unrealized income over the course of a year and over the years to come.[6] As dairy herds become larger in cow numbers, manpower input per cow will decrease and the problem of poor heat detection will become amplified.[7,8] The problem of poor heat detection is also exacerbated by the management practices incurred on today's dairies with total confinement operations and their interaction with the expression of the behavioral signs of estrus. These practices would include cattle on concrete a significant portion of the day, surfaces that are not amenable to adequate footing, confinement housing, daily farm work, and poor training of farm personnel observing estral activity.[9] Where video cameras were used for 24 hour surveillance of mounting activity for cows housed in a freestall barn, 90% of the cows were observed in heat by 60 days after calving.[10] However, less than 50% of the heats were observed visually by the herdsman during normal observation times or heat checks.[10] It was also determined that 70% of the mounting activity occurred between 6:00 PM and 6:00 AM, and 23% of the cows were in standing heat less than 8 hours.[10] Problems associated with heat detection are therefore multifactorial, time for other tasks also takes precedence over detection, added to the fact that producers can't spend 24 hours a day detecting cows in standing heat.

If heat detection is the single greatest limiting factor in a successful artificial insemination program, the justification and expenditure in creating a system that would characterize various physical parameters of estrous (mounting activity), provide suitable management lists for herd monitoring, allow detection on a 24 hour a day surveillance,[6] and be economically warranted, would be unsurpassed in recent years. Most economic reports have suggested that between $75 and $100 are lost when one estrus goes undetected.[7,8] Table 1 below estimates the dollar value and the economic impact of improving the detection of estrus from 50 to 90%.[11] Clearly the need exists to develop new technology that will provide an increase in heat detection efficiency and accuracy. This would eliminate the need for visual observation and unreliable aids for the detection of estrus.[7,8]

The testing of a system at Virginia Tech University called HeatWatch™ (HW) produced by DDx, Inc., Boulder, Colorado and marketed by American Breeders Service, DeForest, Wisconsin, has demonstrated, in our opinion, the characteristics of the ideal system for the accurate and efficient detection of estrus. This paper will identify the characteristics of this system and examine the results we have achieved with this new management tool.

**Table 1.** Estimated additional income ($ per year) when estrous detection efficiency is improved from 50% to 90% at a milk price of $12.50 per hundred weight.

| Herd Ave. (lb milk/yr) | Herd Size 50 | 100 | 200 | 400 | 800 | 1500 | 2000 | 4000 |
|---|---|---|---|---|---|---|---|---|
| | (Value in Dollars) | | | | | | | |
| 15,000 | 2056 | 4113 | 8225 | 14443 | 28885 | 54160 | 72213 | 144426 |
| 17,500 | 2307 | 4615 | 9229 | 18458 | 36916 | 69218 | 92290 | 184580 |
| 20,000 | 2558 | 5116 | 19233 | 20466 | 40931 | 76747 | 102329 | 204657 |
| 22,500 | 2809 | 5618 | 11237 | 22473 | 44947 | 84275 | 112367 | 224734 |
| 25,000 | 3060 | 6120 | 12241 | 24481 | 48962 | 91804 | 122406 | 244811 |
| 27,500 | 3311 | 6622 | 13244 | 26489 | 52978 | 99333 | 132444 | 264888 |

From Senger et al (1991)

## The HeatWatch™ System

HeatWatch™ (HW) is an electronic heat mount detection system which combines electronic pressure sensor-transmitters, a receiver which obtains information from individual cow transmitters when the sensors are activated, and a buffer which stores the data until it is requested. The pressure sensor-transmitters, which are approximately 3/4 of an inch tall by 2 inches wide by 3 inches long, are mounted externally on the tail-head of all breeding eligible cows for the detection of estral behavior. These transmitters will remain attached until the cow is confirmed pregnant by rectal palpation. The receiver or antenna is typically mounted on a elevated structure centrally located on the farm. This structure can be an upright silo, the eave of a barn, or the chimney of the farmhouse. Receiver height and placement is dependent on the terrain of the farm and the location of proximity of the cattle to the receiver. Where the topography of the farm is flat or gently rolling, a transmitter signal can be received for a distance of one-quarter mile. However, in situations where cattle will be outside the recommended distance of the transmitter signal, or where solid structures or terrain may obstruct signal output, a "repeater" is available to relay the signal to the receiver and circumvent these situations. The receiver is then "hard-wired" into the buffer for storage of information, which can then be interrogated by an on-farm computer at the discretion of the farm owner.

## Management of the HeatWatch™ System

All cows eligible for breeding are fitted with a sensor-transmitter device at approximately 45 days in milk. These transmitters are securely contained within a durable, tightly woven, nylon envelope that is sewn to a 10 inch by 8 inch webbed patch. This web-type material is synonymous with a largely porous laundry bag. This patch is then fixed on the cow in the region of the sacrum with glue supplied by American Breeders Service.

An early problem encountered with the "heat patch" was a safe and consistent manner in which to retain the patch on the cow, if indeed, the attachment process failed. Early in the testing of the system, patches and the enclosed transmitters were lost, adding to the cost of the system per cow. Initially, a 12 inch "tail" was sewn to the caudal aspect of the patch, which in turn was secured with elasticon, vetwrap, and even duct tape to the base of the tail. This method worked initially, but required daily observations to ensure the wrap was secure and did not constrict the tail or cause inflammation or irritation to the perineal region.

To alleviate the problems associated with the loss of patches and the cumbersome method of secondary security, Dr. Randal Hinshaw, Ashby Veterinary Service, Mt. Solon, Virginia, developed what has come to be known as the "tail-tie". Using a 4 mm. wide by 18 cm. long, black cable-tie, placed in the fossa lateral to the tail-head, this method has proven to be safe, manageable, and economical to apply. For the past 10 months we have tested this method, replacing less than 5% of the cable ties, with little to no subsequent reaction from the cows.

At Virginia Tech, we place these "tail-ties" at approximately 30 days in milk. This allows ample time for the open incision created by the cable-tie to heal and the inflammation to subside before attachment of the heat patch. Initially, a small trocar was adapted to puncture the skin in the lateral fossa. Currently we use a Buhner needle to make the initial incision and draw the tail-tie back through the incision. We utilize the fossa created by the tuber ischii as the caudolateral boundary, the lateral aspect of the tail head as the medial border, and the medial aspect of the fascia of the superficial gluteal muscle as the lateral border in placing the tail-tie. This area is prepped with betadine soap and scrubbed vigorously to ensure a clean puncture sight. The tail is then elevated in an upward fashion perpendicular to the spine, creating a fold of skin in the lateral fossa in which to place the cable-tie. The Buhner needle is thrust through the fold being careful that its placement will remain in the confines of the predetermined triangulation. We typically place the cable-tie 3/4 of an inch below the upper boundary of the skin fold, thereby creating a 1½ inch tunnel beneath the skin in which to secure the cable-tie. Once the Buhner needle has been placed through the skin fold, 1 to 1½ inches of cable-tie are thread through the eye of the needle and the Buhner and cable-tie is redirected back through the skin. It is important to note, not more than 1½ inch of cable-tie is thread through the needle, because this portion is cut prior to locking the cable tie. When the cable tie is thrust back through the incision site, it crimps, making it impossible to thread the cable end through the locking mechanism. The tie is then locked leaving a 1 to 1½ inch diameter circle, with the remainder of the tie cut approximately ½ inch above the locking mechanism. A topical antibacterial spray is then applied to the area of the cable-tie and incision site.

Once the tail-tie is in place for approximately 10 days, the sensor-transmitter and patch unit are applied. A 24 gauge, stainless steel wire is then secured to the caudal aspect of the patch unit and to the cable-tie. Previously, upholstery thread was used, but was quickly abandoned because of deterioration. Other items used are heavy braided fishing line (30 pound test), or a heavy nylon line similar to #3 Vetaphil. Currently black cable-ties are utilized to decrease deterioration from ultraviolet light.

Care should be taken not to apply the cable-tie outside the area of the fossa. In our experience, and observations on commercial farms using the system, when ties are placed outside this designated area, migration of the tail-tie through the skin is more frequent. With proper placement in the fossa, the tail-tie is below the level of the body surface of the cow and is therefore protected even in the event of numerous mounts. We have observed ties placed too far cranial, which subsequently ripped-out during mounting activity. If the ties are placed too far laterally, in the area of the superficial gluteal muscle, or located on the tuber ischii, the tendency is toward a higher rate of replacement. We feel the major reason for this is the tense skin located in this area and the lack of an adequate "cushion" of subcutaneous tissue.

The HW system is currently being utilized for heat detection in replacement heifers. The heifers appear to have a slightly higher incidence of irritation from the cable-tie and should be monitored more frequently for discharge from the incision site. We have eliminated some of this problem by clipping the fossa area with a #40 blade, and flushing the incision site with a 3% betadine solution for 3 to 5 days post-insertion.

This method has been proven safe for cows or heifers, and again, less than 5% of the cable-ties have been replaced. We began October 1994 placing these cable ties and are monitoring their longevity. Currently, essentially all animals have retained their ties and we anticipated using them through an additional lactation.

Cable-ties have eliminated the need for the "tail-wrap" procedure and serve as a secondary security system for patches that become detached. Of the 213 cows with heat patches over the previous 10 months, only 3 have been totally lost. Milkers and cattle-movers are assigned the job of visually observing a detached patch suspended by the cable-tie and notifying the appropriate personnel for regluing. Our experiences have indicated that the longevity of the patch is directly related to the number of mounts experienced by the estral cow. Therefore, if the patch is found to be detached, a review of the HW management file usually indicates the cow has had estral activity. We do experience the occasional patch with localized areas of detachment. These cows are confined in a free-stall and glue is reapplied to the faulty area of the patch. Most of the detachment occurs in the area directly lateral to and adjacent to the tailhead, especially in cattle with body condition scores less than a 2.75. This is a result of the width of the transmitters and a lack of direct contact with the curved tailhead and body surface in this area.

At the current time, we have an ongoing project to determine the longevity of the cable-ties, the duration of heat patch placement, optimal materials for the patch, and the amount of time delegated to management of the "cow-side" of the system. In our estimate, this time would be in the range of 24 minutes per day. This time allotment would also include checking the system for the purpose of heat detection, as well as attaching the patches to new breeding eligible cows, reattaching patches, "spot-gluing" patches, and removing patches from confirmed pregnant cows.

### Management Reports Available from HeatWatch™

The HW system records the time of day and the duration in seconds of each mount an animal receives. The system has two major lists pertaining to heat detection to be monitored on a daily basis. These two lists would include a "suspect heat list" and a "standing heat list". Default settings using the number of mounts in a predetermined time period and the duration of each individual mount are used to place a cow in one of the two categories. These default settings are dependent on individual farm management schemes and individual producer and veterinarian experience may be more of a guide to determine where these defaults are placed. For example, a suspect cow may have 2 mounts of an average 3 second duration in a 4 hour period. An additional cow, at the discretion of the owner, may default to the heat list if she has 3 mounts of an average 3 second duration in a 4 hour period. Whether a "suspect cow" is determined to be in heat would be dependent on prostaglandin programs and the number of days since an injection was administered, number of days since the last recorded heat, and the duration of mounting activity. Other key reports would include a herd inventory of all cows that have or have had a transmitter device, and a breeding summary and list by technicians and bulls. Reports are also available in graphic form. The ability to transfer this information to an on-farm computer system or a DHIA record system is available. There are several other reports available, that will be unreported in this article.

From this information, we have extracted some representative measurements of mounting activity such as totals mounts, mounts ≥ 2 seconds, average duration of mounting activity, and the duration of estral activity. In addition, graphs were made to illustrate the effect of management and estrous detection times on mounting activity. (Figure 1).[6] This graph demonstrated that the highest estral activity or frequencies of mounting occurred when cows were moved from concrete to dirt surfaces between the hours of 8 AM and 9 AM (time of day for visual observations of estral activity at Virginia Tech). Other times when activity were observed to be high were at 12 noon and 12 midnight (shown as 0 and 12 respectively on the graph). These times coincide with traveling to and from the milking parlor on a dirt lane. Lowest frequency occurred when cows were locked in the free-stall area for feeding times and waste feed removal. When cows were locked in the free-stall area sometime between 10 AM and 12 noon, little to no mounting activity was recorded, because of the close quarters, inadequate footing, and presumably because cows were lying down. After returning from the milking parlor at approximately 3 to 4 PM, cows were at the feed bunk with little to no activity recorded. This clearly demonstrates the interaction of management and mounting activity and the role management plays in estral display.

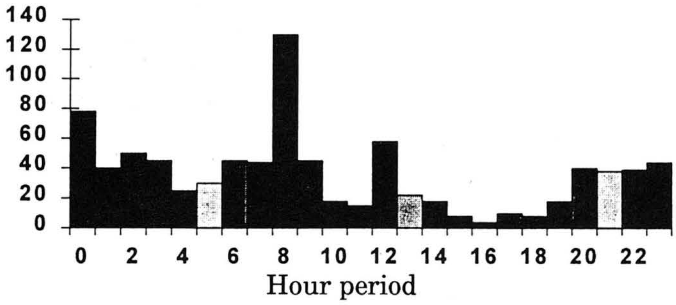


**Figure 1.** (Walker *et al* 1995) Frequency of Mounting Activity.

Based on our observations, a cow has approximately 10 mounts for an average 2 second duration per mount in a 9 to 10 hour estral period. These values are slightly lower than previous reports in the literature with studies using frequent visual detection or video cameras or previous HW systems. We believe this is a difference due to the sensitivity of the system and management effects. The system is setup such that mounts less than one second are not recorded. This should eliminate erroneous mounting activity by correcting for bumping the transmitter on a free stall, chin resting in the holding area, or transient riding. Previous versions of the HW system were much more sensitive to slight touch, meaning any pressure to the sensor would be recorded as mounting activity. Management plays a role owing to the fact cows are on a concrete lot an average of 20 to 22 hours a day. When many of the earlier studies were performed, cows may have been managed in a very different scheme. Therefore, footing surfaces and other management practices probably weren't the same as they are today. So, in effect, we may be dealing with a very different management style and type of animal. Is their estral activity, number of mounts, duration of mounts and duration of estral activity the same as for a cow 10 years ago? In looking at our overall numbers, you can appreciate just how little activity cows exhibit when they are in heat. Total estral activity or duration is also quite different than previously reported. Rather than the previously reported 12 to 18 hour duration of estrus, our findings indicate ≥ 70% of the cows are in estrus for less than 12 hours (Figure 2).[6] This coupled with mounting activity makes visual observation that much more of a challenge.

Y Axis = Frequency (%)

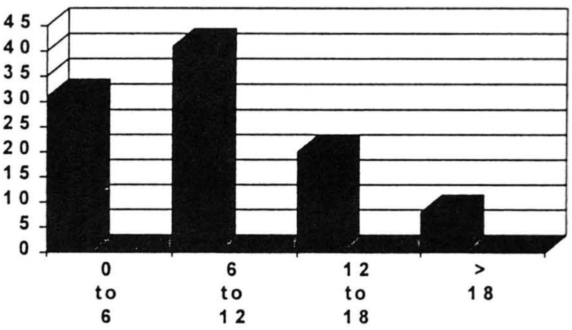


**Figure 2.** (Walker *et al* 1995) Estrus duration as determined by HeatWatch™

## How Good is HeatWatch™ for Efficiency and Accuracy?

HeatWatch™ has been tested at Virginia Tech against the management practice of twice daily visual observation. As in the vast majority of herds in Virginia, visual observation yielded a 43% heat detection efficiency. Visual observations would also include greater than a 90% heat detection accuracy based on farm records in our herd. In ongoing studies at Virginia Tech, we would conclude that the HeatWatch™ system is efficient at the level of 94% with a 95% heat detection accuracy. We have used the system in the total herd since October of 1994. Our final results are yet to be determined, however, based on observation of DHIA records, days open have decreased by ≥ 30 days, pregnancy rates have increased 20%, and services per pregnancy have decreased 0.5. We recognize days open is not an indication of reproductive efficiency because of culling efforts, however, it is a language that producers can understand. When we stratify our cows by projected calving intervals, less than 21% of all cows have greater than a 14 month calving interval or 155 days open. Pregnancy rates are currently at 88% with services pre pregnancy at 1.5. We feel our pregnancy rates are a direct result of increased heat detection efficiency and the services per pregnancy are a result of knowing exactly when cows exhibit their first mounting activity resulting in better timing of insemination. Ongoing projects in this area are being conducted to ascertain the optimal time for insemination.

## The Economics of HeatWatch™

If we are to assume that the average cost of a day open (again producer language) is a minimum of $2.00 per day, and the average for heat detection efficiency is 50%, again the average in Virginia is 43%, and the average herd size in Virginia is 120 cows, with a conception rate of 50%, the unrealized gains by increasing heat detection to ≥ 90% would be approximately $7600.00

per year (Table 2).[12] To install the HW System in this size herd would cost approximately $6000.00, giving a potential payout in the first 10 months of operation. Again from Senger's work demonstrating one missed heat is a #75.00 loss[7,8] and the average heat detection efficiency is 50%, or 1 out of every 2 heats is missed, with a services per pregnancy of 2, this would equate to a $150.00 loss per cow on a yearly basis. This is a much larger figure than the previous illustration using days open. At any rate, if the system is properly managed and maintained, the average farm could benefit significantly from the HeatWatch™ system. Is it for everyone? The answer is a resounding NO! Careful record analysis and evaluation of the herds reproductive efficiency is the only way to determine if the system is cost effective.

**Table 2.** Expected days open at conception based on probability of estrus detection and AI conception rate (AICR) assuming 60-d VWP, 21-d estrous cycle, and maximum of 9 cycles (260 expected days open).

| | Estrus detection probability | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| AICR (%) | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
| 30 | 234 | 211 | 192 | 176 | 162 | 150 | 140 | 131 | 123 |
| 50 | 218 | 186 | 162 | 143 | 128 | 117 | 108 | 101 | 96 |
| 70 | 204 | 166 | 140 | 121 | 108 | 99 | 92 | 86 | 82 |

Adapted from Pecsok, *et al.*, 1994, *J. Dairy Sci.*, 77(10), pp. 3008-3015.

### Summary

The results of our studies illustrate a few important points very clearly. The HW system, if managed properly, can be an effective management tool for estrus detection, eliminating the need for labor dependent visual observation. Timing of insemination can now be performed relative to the accurately measured occurrence of first mount of standing heat or the estrus period. This system would eliminate the need for extra-label drug interdiction for timing of insemination. Finally, the system clearly demonstrates how little time cows are in heat, the difference in duration of heat from cow to cow, how few mounts a cow exhibits while in standing heat, and that heat detection can be accomplished after hours or while other chores are being performed. **Overall, we feel this system can improve heat detection and help "factor out" estrous detection failure as a culprit in high reproductive culling, low pregnancy rates, and excessive days open within the herd.**

Senger *et al* published the requirements of the ideal system for the detection of estrus.[7,8] This system would include (1) 24 hour a day surveillance (2) accurate and automatic identification of the cow in estrus (3) operation for the productive lifetime of the cow (4) minimized labor requirements an (5) high accuracy (95%) at identifying the appropriate physiologic or behavioral events that correlate highly with ovulation.[7,8] We feel HeatWatch™ meets or exceeds all of the preceding set of criteria, with the following exception. HW cannot be applied for the productive lifetime of the cow. Patches are applied only to breeding eligible animals and are only removed after the animal is confirmed pregnant. However, there is not a system currently available on the market that meets this requirement. Such a system would require surgical implantation and permanent installation, probably in the heifer calf, and would remain until the animal was culled and sent to market.[7,8] Senger illustrates how implantable devices exist in humans, (pacemakers, artificial joints, drug and hormone releasing devices), however, the use of such devices in food producing animals is strictly prohibited by the Food and Drug Administration. Implantable devices would need to be biocompatible, present no discomfort to the animal, remain in the proper anatomical location for the duration of the life of the animal, the components could not be released into the animal and the device would need to be easily retrieved prior to slaughter.[7,8] Clearly in today's climate of consumer awareness and animal well-being, an implantable device is met with some tremendous hurdles to overcome before USDA and FDA approval is forthcoming.

The HeatWatch™ is not by any means without related problems. It also has inherent situations that need to be addressed. Initially, the batteries had a longevity of approximately 6 months. Currently, the life expectancy is greater than 1 year. Without a secondary attachment system, the cable-ties, a producer may expect to lose ≥10% of the sensor-transmitter devices. This can lead to costly expenditure incurred per cow for the system and producer frustration with the system. Because the system is not an interrogation device, HW relies on transmission from the cow to the antenna. The current system is working well for a range of 1/4 mile, where the landscape is flat and unimpeded by physical structures. Repeaters are available for these situations, but do add to the cost of the system. The system has not been tested under controlled situations in high density herds or herds greater than 400 cows. Our recommendations are currently to have at least a 40% rate of transmitters for every cow in the herd. In a 1000 cow herd, a requirement of 400 transmitters would be necessary for heat detection. This would entail a tremendous initial investment or capital outlay. Further work needs to be investigated on management techniques for the larger herds to minimize the number of transmitters required to maximize the efficiency of the system. In addition to these requirements, seasonally calving herds would require a higher rate of transmitters. If a producer is calving a high percentage of cows in the fall, this would concentrate heat detection into a narrow window of time, requiring more transmitters for this period and transmitters being shelved at other times of the year. There is also a learning curve associated with interpretation of the HeatWatch™ data, primarily the incidence of false positives and individual herd default settings to meet the producer's management style and needs. This would mean individuals evaluating the system's data will still be met with some breeding management decisions, as this is not the "perfect system" nor is the data clearly "black and white".

**There is clearly the need for more controlled studies to address these problems and define the strengths and weaknesses of the system. Our ongoing research efforts at Virginia Tech are encouraging and will hopefully address some of these concerns.**

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# Abstract

## Persistence of bovine herpesvirus-1-specific antibodies in cattle after intranasal vaccination with a live virus vaccine

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To study the development and persistence of circulating antibodies directed against bovine herpesvirus-1 (BHV-1) induced by vaccination, approximately 80 per cent of the seronegative cows in four partly seronegative dairy herds were vaccinated once with a temperature-sensitive live virus vaccine. Most (83 per cent) of the vaccinated animals developed antibodies to BHV-1 within two months after the vaccination. In the same period, 21 per cent of the unvaccinated control cattle also seroconverted, suggesting that the vaccine virus had been transmitted to them. Thirty months after they had been vaccinated 91 per cent of the vaccinated animals with responded still had detectable antibodies. The results suggest that vaccine-induced antibodies may persist for years and thus may interfere with control programmes for BHV-1 which are based on serological monitoring.