Nedap **CowControl™**

Health monitoring and management with the smarttag neck

nedap

KNOWLEDGE PAPER

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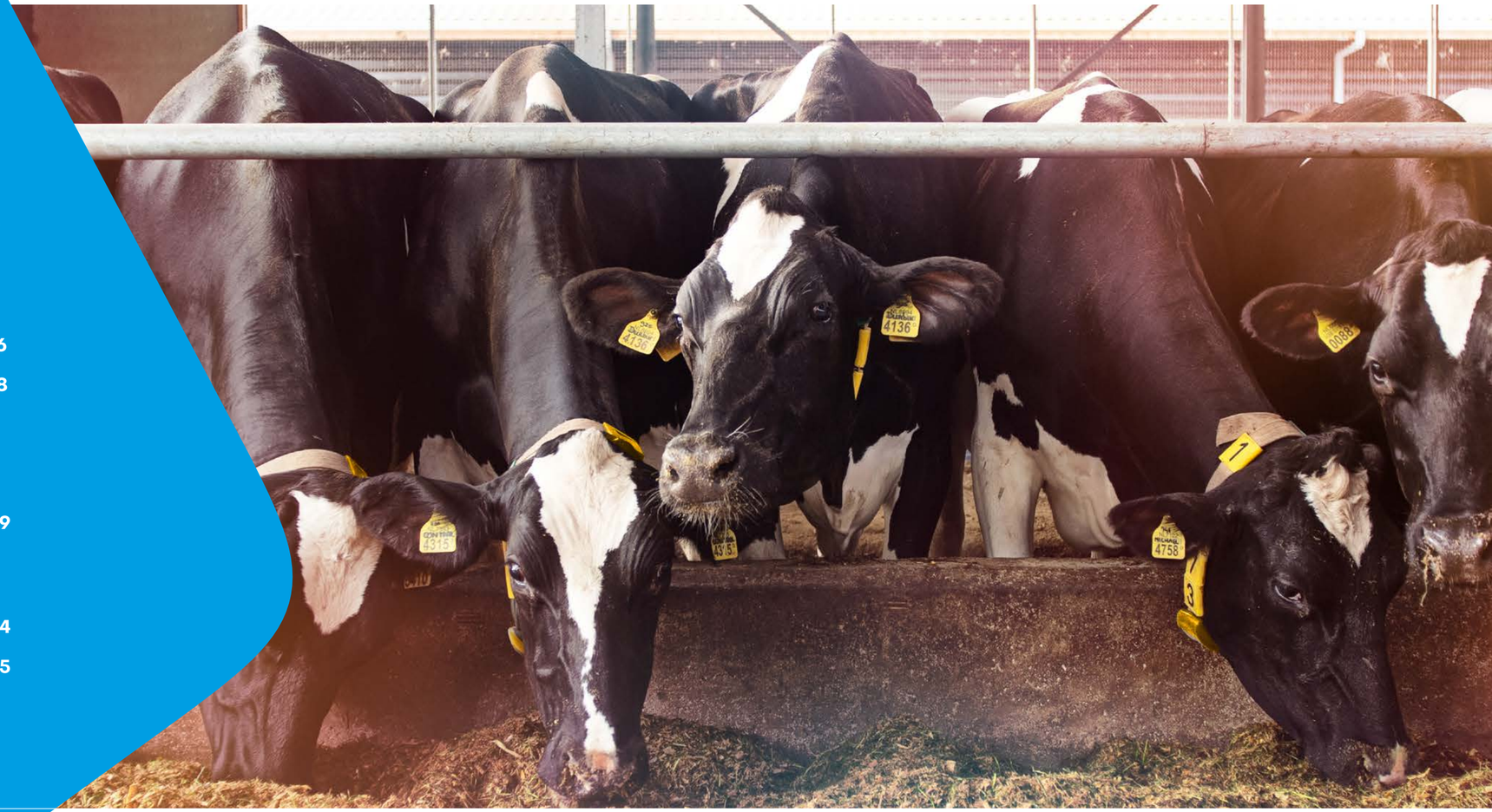


Introduction

In a perfect world, all cows on a dairy would behave in an ideal manner, thereby producing the maximum quantity of milk possible. However, in practice there are many factors preventing that ideal situation from being achieved. By monitoring and analyzing the behavior of cows, the well-being of a cow or group of cows can be determined in an extremely precise way and the analysis can be used to identify bottlenecks.

Behavior monitoring is something that dairy farmers, herd managers, veterinarians and consultants have been doing for years. The use of sensor technology means that cow monitoring can now be streamlined and performed automatically. Insight and information can now be obtained and evaluated 24 hours a day, seven days a week.

Optimum cow behavior per day:[1]

- 4-6 hours eating
- 9-14 meals
- 7-10 hours ruminating
- 12-14 hours lying down
- 11 periods of lying down
- 2.500-3.000 steps

Optimizing the health, fertility, nutrition and management of each individual cow and the entire herd is key to dairy farm profitability. Nedap COWcontrol ™ is the all-in-one herd monitoring and management system that empowers dairy farmers, herd managers and farm staff with automated Health Monitoring, Heat Detection, Cow Positioning, Identification and management insights. The Smarttag Neck measures four aspects – and their mutual interaction - of the cow's behavior related to her health: eating, rumination, inactivity and other activity. The actionable information and valuable insights they provide contribute to optimal dairy farm performance and profitability.
This knowledge paper describes the importance, use and advantages of Health Monitoring and Management with the Nedap Smarttag Neck at the operational, tactical and strategic level.

Dairy cow behavior and its relations

Each cow's behavior is influenced by a variety of factors. The characteristics associated with each cow – such as health, reproduction, stress, rank within the herd and character – can be distinguished. External factors – such as barn surroundings, milking equipment, the milking process, feeding management and climate – may also affect an individual cow's behavior.

External factors
(environment management)
Barn surroundings, milking equipment, milking process, feed management, climate, etc.

Behavior
Lying, standing, walking, eating, rumination, inactivity, other activity

Cow-related factors
Health, reproduction, stress, ranking, character

Cow health

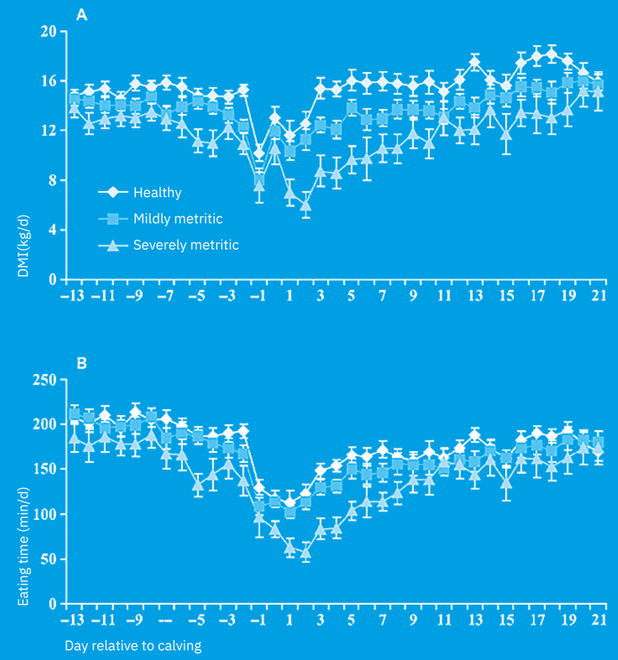
Sickness affects a cows behavior. Research carried out by J.M. Huzzy showed that cows suffering from metritis spend less time eating than healthy cows. For cows with a displaced abomasum, both the time spent eating and ruminating decrease substantially, and in the case of lameness, cows adjust their daily routine because standing is painful.

The effects of mastitis and its effect on a cow's behavior are extremely diverse. Without displaying any clinical symptoms, cows can be stressed, suffer from localized conditions, such as a painful udder, or produce abnormal milk.

The types of behavioral abnormalities depend on the severity of the condition. Sensor technology can assist livestock farmers in detecting abnormal behavior. Although cattle behavior is closely related to the health of an individual cow, a correct diagnosis requires the herd manager and the sensor technology to work together. The system highlights which cows require more detailed examination. This allows the herd manager to complete clinical checks to determine a cows situation and provide her proper treatment.

Figure 2: Arithmetic mean (± SE) daily DMI (kg/d; A) and eating time (min/d; B) of healthy n = 23), mildly metritic (n = 27), and severely metritic (n = 12) Holstein dairy cows from 13 d before until 21 d after calving.2

Cows that develop metritis after calving eat less and for shorter periods of time. During the dry period, they were already eating for shorter periods of time, especially when compared to healthy cows from within their group.2



The history of the dairy cow and the importance of rumen health

The ancestors of modern-day dairy cows lived on large prairies and plains where they grazed plants that other animals could not digest. Mammals with a single stomach are either unable or minimally able to digest the cell walls of such plants, like hay and grass. A cow also could not digest this type of plants without micro-organisms in the rumen. In cattle, micro-organisms can break down the cell walls of those plants into useful nutrients. The cow absorbs those nutrients and converts them into valuable products, such as milk and meat. This process can occur because a cow's stomachs contain a greater number of micro-organisms than there are humans on earth.

Cow feed must contain the right balance of nutrients so micro-organisms can work effectively. If the micro-organisms receive the right types of nutrients, the cow can gain maximum nutritional benefit from the feed it digests.

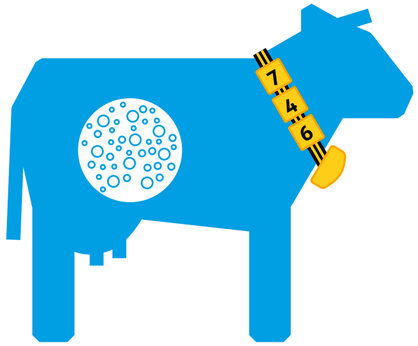


Figure 3: The cow's rumen.

Optimum rumen health (a stable and active population of micro-organisms in the cow's rumen) results in a high degree of efficiency and ensures cows are in good health. The health of a cow's rumen is affected by the feed, the cow's buffering capacity and the dairy's feeding management. The health of the rumen is expressed by referring to the acidity in the rumen: the rumen pH.

The optimum rumen pH is ideally between 6.2 and 6.5 during the day.3 Within this pH range, microflora in the rumen operate at maximum efficiency, breaking down the nutrients from the feed. Continuous feeding problems may cause a low rumen pH, which may lead to sub-acute ruminal acidosis (SARA). SARA can cause anorexia, diarrhea, heart palpitations, and death in extreme cases.[4]

SARA can also lead to potential problems such as reduced milk production, lameness, mastitis and reduced fertility.[4]

The type of feed can also determine the rumen pH of a cow. The rumen pH can be affected by acid-forming feedstuffs, such as grain-based feed concentrates which contain large quantities of carbohydrates. The correct ratio of roughage/fiber to concentrates and the effective distribution of feed across the day will lead to a rumen pH that is both stable and correct.[5]

To a certain degree, cows can control their rumen pH. The rumen wall partially absorbs acid-forming feed components or removes them by passing through to the intestines.[6]

The rumen can cope with changes in feed rations if they are gradual. Significant changes from a diet low in acidifying nutrients to one containing large quantities may result in rumen acidosis.

The degree of which acid components are removed depends on the type of feed the cow has consumed recently. This situation applies during a transition from a diet for non-lactating cows to a diet for lactating cows.

Buffering of the rumen pH takes place through rumination, when a cow produces more saliva. Cow saliva contains sodium bicarbonate and has a pH of 8.2. As a result of this high pH, acid is buffered in the rumen, which is why rumination is important for a cow. A healthy cow adequately ruminating will produce up to 150 liters of saliva per day. Feeding sufficient roughage will encourage the cow to ruminate, increasing its saliva production. Feeding concentrates will cause a decrease in rumination causing a reduction in saliva production. Ruminating for about 40% of the times is essential for a cow to maintain a healthy rumen.[7]

The riskiest period of acidification in the rumen is at the start of a lactation. The significant increase in milk production means more energy is needed, which must be provided by feeding concentrates. The cow's ability to absorb feed is also under pressure. During the start of a lactation, providing a proper balance of feeding and management can help maintain a healthy rumen. Monitoring the time spent eating and ruminating therefore is an effective tool.

Studies researching SARA suggest that meal size is an extremely important aspect of nutritional management. Cows can self-regulate their ruminal pH effectively if they have continuous and predictable access to the same total mixed ration (TMR) every day. However, modest feed restriction can cause cows to consume meals that are too large. Therefore, good feed bunk management practices are critical to prevent SARA. Even when chemical fiber, particle length, and grain processing are optimal.[8]

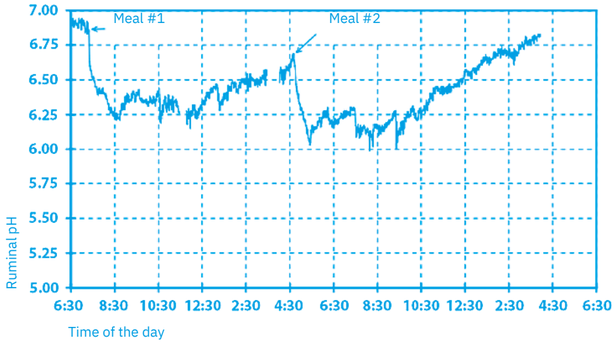


Figure 4: Effects of meals on rumen pH1.

Optimum time spent by a cow

A cow is healthy and productive if she spends her days in the most effective way.

Optimum cow behavior per day has been examined to include: 1 - 4-6 hours of eating - 9-14 meals - 7-10 hours of rumination - 12-14 hours of lying down - 11 periods of lying down - 2.500-3.000 steps. In addition, a cow will spend time drinking, being milked and socially interacting.

Highly productive dairy cows, housed in a freestall, will spend between four and six hours a day eating. Their total eating time will be distributed across nine to fourteen eating sessions or meal times during the course of the day.[9]

Brotheras, NA., 2007.[9]

Situations affecting the time a cow spends on various activities may reduce the time

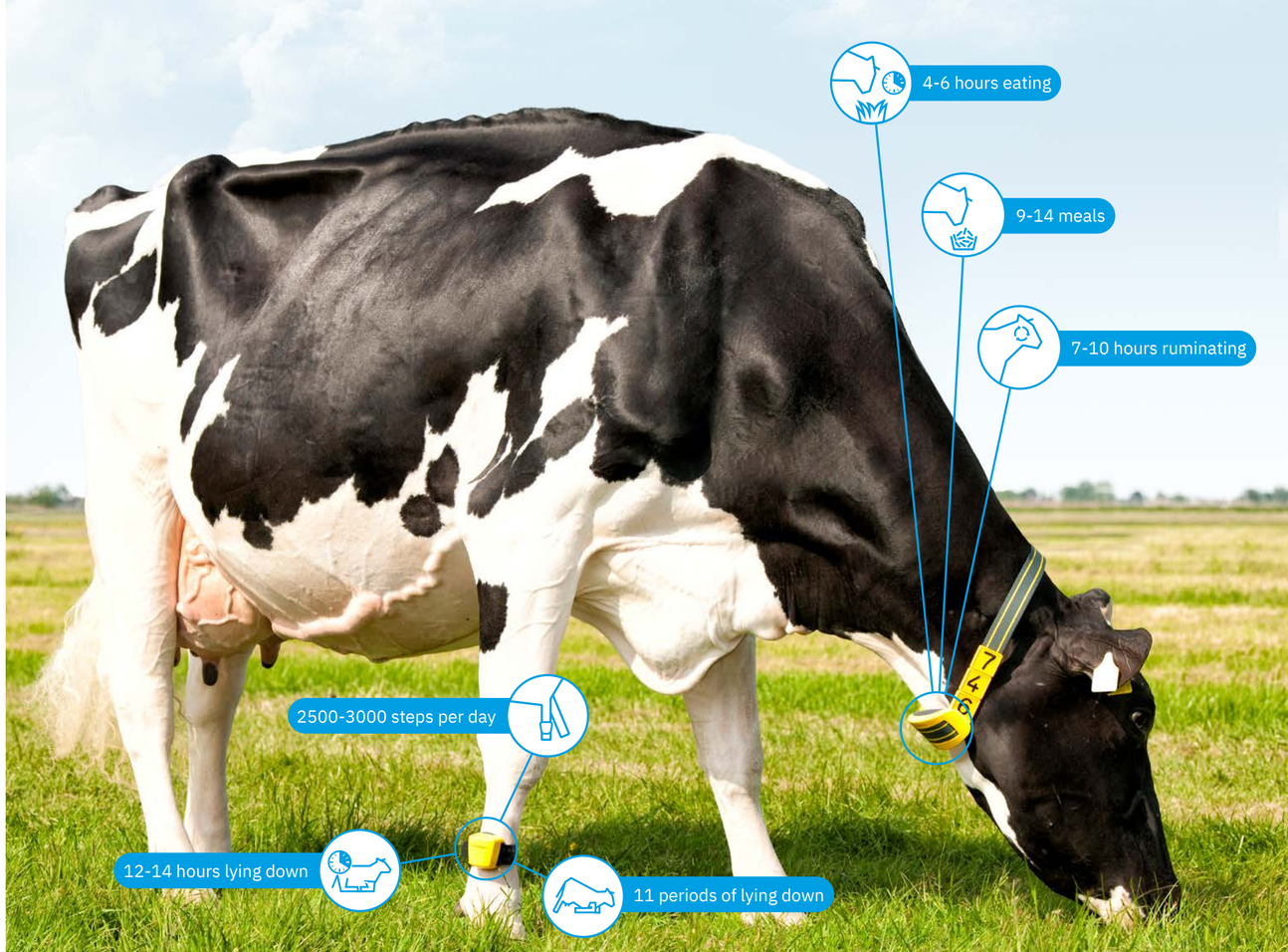
the cow can spend on other types of behavior. Such situations may include excessive milking time, being locked at the feed bunk, having no access to roughage or overcrowding. These situations may have a negative effect on the cow's milk production.

Poorly designed or poorly managed facilities and installations may affect normal social interaction. Changes to lying behavior in cattle may result in longer periods of standing.[10] *For example, over-occupied and long waiting times before milking influence the time cows have available for eating and lying down.*[10]

Deming, JA., Bergeron, R., Leslie, DE., De Vries TJ., 2013.[10]

Also, group behavior can be affected by external circumstances, limiting normal cow behavior of multiple cows. Possible reasons why a group of cows spends less time eating and ruminating.

- Limited access to water[11]
- Limited access to feed[12]
- Limited availability of feed
- High incidence of lameness[13]
- Poor dietary fiber content in the feed[14]



Feeding management

Good diet and feed provision form the basic requirements to ensure cows are healthy and highly productive. Therefore, all cows in a group must have the opportunity to eat at any time, without limitations.

The type of cows with a greater risk of reduced feed intake are newly introduced heifers, fresh cows, sick cows and lame cows. These cows will be the last to have the chance to eat due to the competition that exists at the feed bunk. Another problem is that other dairy cows are selective about what types of feed they eat. Therefore, the at-risk cows will only receive the remaining feed the other cows have left; the best feed is gone and the content of the remaining feed is often lower quality.15 Adjusting feeding management by reducing crowding at the feed bunk, feeding more often, feeding at different times or by allowing more residual feed, may lead to improvement of feed intake and the type of fresh feed the at-risk cows eat. [15]

Below is an example showing how feeding management can affect eating behavior. This type of data can be used to demonstrate how cows eat and to monitor the effects it causes.[15]

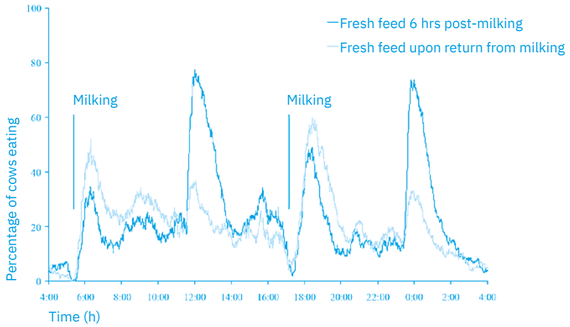


Figure 5: Percentage of cows per group present at the feed bunk over a 24-h period (percentage for each 60-s interval during the day) for 2 treatments: 1) cows were milked and fed at 0530 and 1730 h, and 2) cows were milked at 0530 and 1730 h and fed at 1130 h and 2130 h. Data were averaged for 7 d per treatment for 4 groups, each containing 12 cows. Data are presented from 0400 h, since this was a time of low feeding activity for both treatments.[15]

Information at the operational, tactical and strategic level

Nedap COWcontrol ™ provides the herd manager with information on the following levels:

- Operational
- Tactical
- Strategic

The Nedap Smarttag Neck, part of Nedap COWcontrol ™, monitors six aspects of cow behavior 24/7:

1 Location
2 Heat signs
3 Eating
4 Rumination
5 Inactivity
6 Other activity

The behavioral aspects Eating, Rumination, Inactivity and Other activity are health related.

Figure 6: Nedap Smarttag Neck – 24/7 monitoring of cow behavior. Health-related parameters shown in a 48-hour overview in the Nedap user interface.

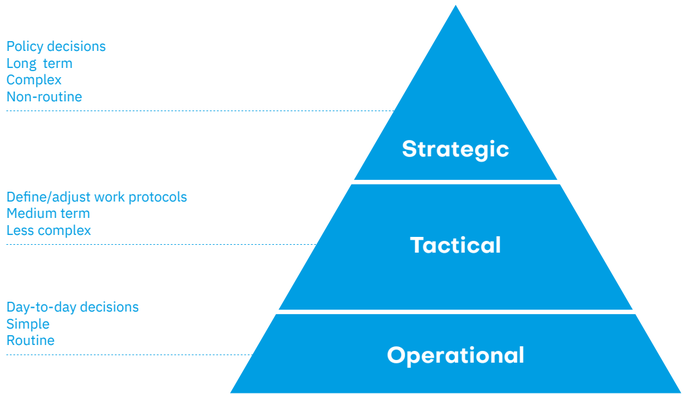


Figure 7: Management levels and information demand.

These health measurement processes have been validated by Wageningen University.[16] The ability to know various cow behaviors and their interaction provides a complete picture of an individual cow's health status, an individual cow in relation to its group members or the group. Information obtained using the Smarttag Neck can be used daily for operational management purposes. Every day, the dairy farmer or herd manager will be provided with an overview of the cows displaying abnormal behavior. The ability to view the welfare of individual cows as well as the accuracy and efficiency of the sensor technology will ensure it becomes an important part of everyday farm protocols (various examples of dairy farm protocols are provided in this paper).

The data about the behavior of dairy cows can also be used to optimize the management on a farm at a tactical and strategic level. Interpretation of tactical and strategic information must be completed in its own way. To present this to the dairy farmer or herd manager clearly and concisely, Nedap has developed its COWcontrol™ solution.

Operational level

Cows on a dairy farm can deliver peak performance daily. Every day, a cow can produce about 10% of her bodyweight in milk. To deliver that level of performance, cows must be in top condition, which is the responsibility of every dairy farmer/herd manager. Nedap COWcontrol™ provides information about the behavior of dairy cows. The dairy farmer or herd manager can use that information to carry out his or her tasks, and those of their staff, more effectively and efficiently.

Urgent intervention

Many activities performed on a dairy farm are tasks and protocols carried out daily. Incidental tasks aside, urgent matters may arise that require immediate intervention by the dairy farmer or herd manager. The health of the herd is one important example. Nedap COWcontrol ™ measures a unique number and combination of aspects of cow behavior. If a cow suddenly stops eating, ruminating or displaying any other type of active behavior, this is (almost) always an indication of an issue relating to that cow. In such situations, Nedap COWcontrol ™ sends an urgent alert to the dairy farmer or herd manager. He or she can then take immediate action based on the alert received. Research has demonstrated that the alerts issued by the system are both accurate and effective.

Figure 8: Display signaling a cow with need for urgent attention, because she shows inactive behavior for too long. At the top the 48-hour overview of the cow is displayed. Below the day totals of the past 60 days regarding eating, rumination and inactive behavior. The horizontal line in the day totals shows the average of the entire group of cows that she is in. The farmer or herd manager determines in the adjustable settings when he or she wants to receive an alert (for instance when a cow is showing inactive behavior for 6 hours) and whether he or she wants to receive an alert via e-mail (or SMS) in addition to the alert in the Nedap user interface.

The possible reasons why a cow suddenly stops eating and/or ruminating:

- E. coli mastitis
- Milk fever
- Acute ketosis
- Hardware disease
- Lameness
- Displaced abomasum

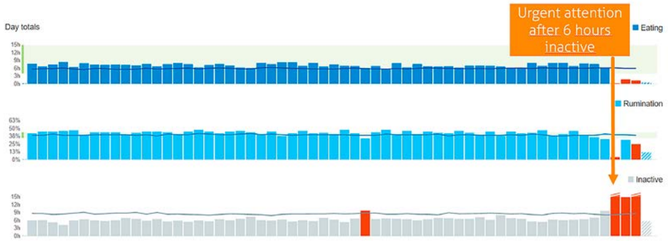


Figure 9: Example of a cow suffering from an E. coli infection.

Farm protocols

In addition to a well-organized process, successful daily use of sensors requires excellent sensors and detection of algorithms. The dairy farmer or herd manager must be aware of what should be done whenever an issue occurs. He or she also needs to have access to all the relevant information and tools needed to make and implement decisions at the practical level. The overall picture is what counts and matters. Setting up and using clear farm protocols is important for the farmer or herd manager and the staff to know what action should be taken in case of a particular alert. It maximizes the benefits of the system.

System design must be based on the optimum interaction between the dairy farmer or herd manager and the system itself. This white paper provides sample protocols for the types of decisions that can be made at each level. The dairy farmer or herd manager can utilize these within his or her own operational processes.

Figure 10: Sensor data adds value to farm protocols and vice versa.

Support during daily work

In addition to issuing alerts for urgent attention, Nedap COWcontrol ™ also helps dairy farmers or herd managers perform recurring management tasks.

Risk group - recently calved cows

Recently calved cows form a risk group. During this transitional period between calving and producing large quantities of milk, cows are more vulnerable to bacteria and diseases. Ensuring lactation is off to a good and healthy start will enable cows to remain productive longer and produce higher yields. This yield continues even during subsequent lactations.

Monitoring the behavior of recently calved cows enables dairy farmers or herd managers to identify which cows need extra attention during this risky transition period.

A decrease in the time spent eating and ruminating around calving time is acceptable, but that drop must not continue for too long. After calving, an increase in eating time must take place to meet the energy requirements of the cow.

Too little time spent eating and ruminating may indicate health problems relating to calving, such as milk fever, dystocia or difficult calving, retained placenta or mastitis.

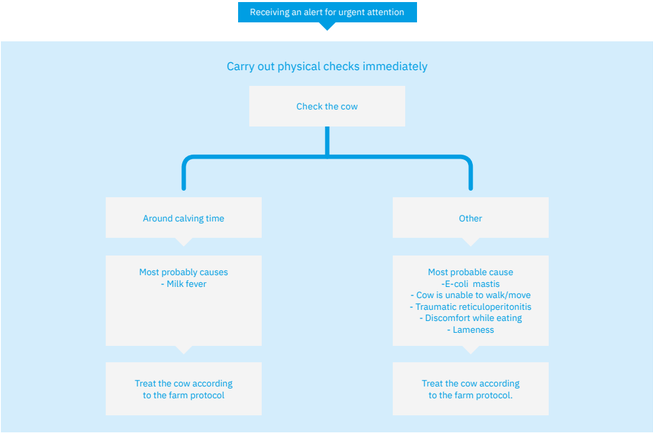


Figure 11: Protocol detailing what action to take when receiving an urgent attention.

The Nedap COWcontrol ™ system provides the dairy farmer or herd manager and his or her employees with valuable information regarding critical factors determining rumen health. It also provides information about the effective distribution of feed intake throughout the day and the extent to which an individual cow or the entire group is ruminating, meaning the health of the rumen can be monitored on a continuous basis. And the farmer can act at an early stage to prevent potential problems. This applies both to the transition period and to the entire production cycle of the cow.

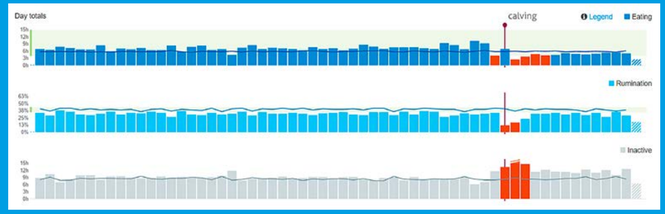


Figure 12: example of a cow having difficulties starting her new lactation. She is showing an eating & rumination drop and increase of inactive behavior after calving.

Figure 13: An overview of 'animals to check today' that need attention.

Post-treatment recovery

Any observation of a cow is simply a snapshot. It does not provide any information about what the cow was doing before the observation was made. That is why post-treatment checks are a difficult task. If some cows in a group received treatment, it is difficult to monitor the feed intake and rumination of each cow. It is impossible to see whether a cow that received treatment is eating and ruminating sufficiently.

Continuous monitoring with the support of sensors helps the dairy farmer or herd manager monitor whether a treatment has been effective or not effective. For example, if a cow has been treated for a displaced abomasum, monitoring to ensure sufficient rumination is preformed is an important indicator of recovery. Adequate eating and rumination is also an important indicator of recovery from other health issues.

Nedap COWcontrol ™ enables dairy farmers and herd managers to monitor the information that the system provides during the week before calving and for two weeks after calving. Cows showing any change in eating behavior and rumination pattern can then undergo an additional clinical examination to stay one step ahead of additional serious problems.

Figure 14: The farmer can act at an early stage to prevent problems with cow 295.

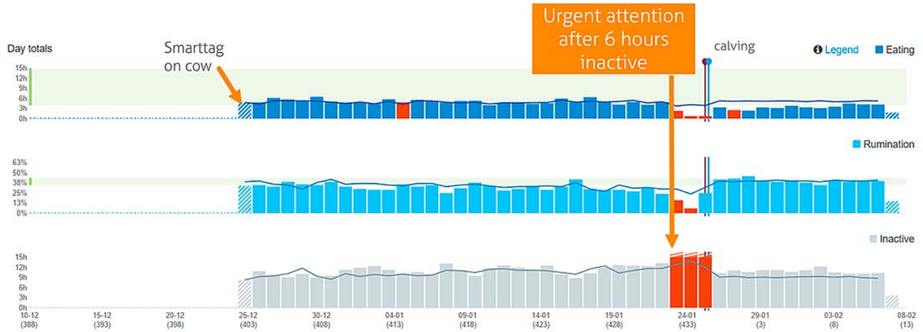


Figure 15: Example of a cow suffering from milk fever and recovering after a calcium injection.

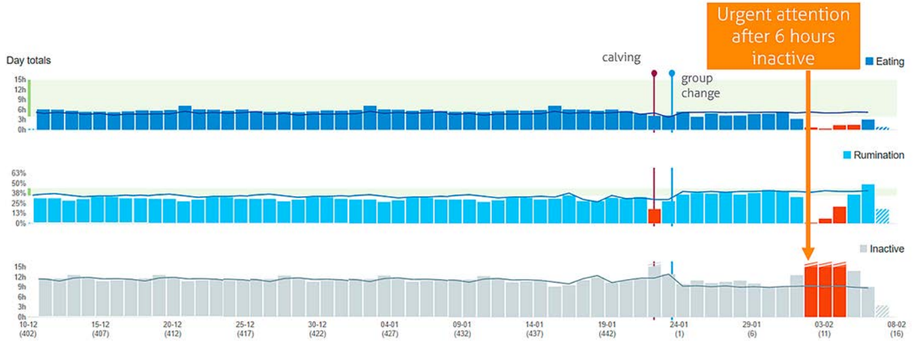


Figure 16: Example of a cow suffering from a displaced abomasum and recovering after operation.

It is recommended that the dairy farmer or herd manager integrates the sample procedure below to their farm protocols.

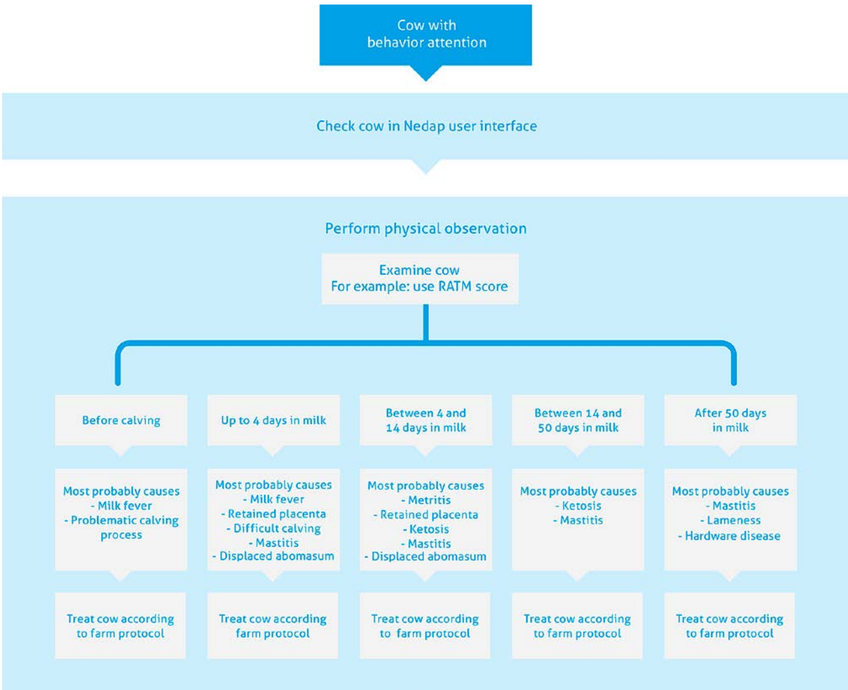
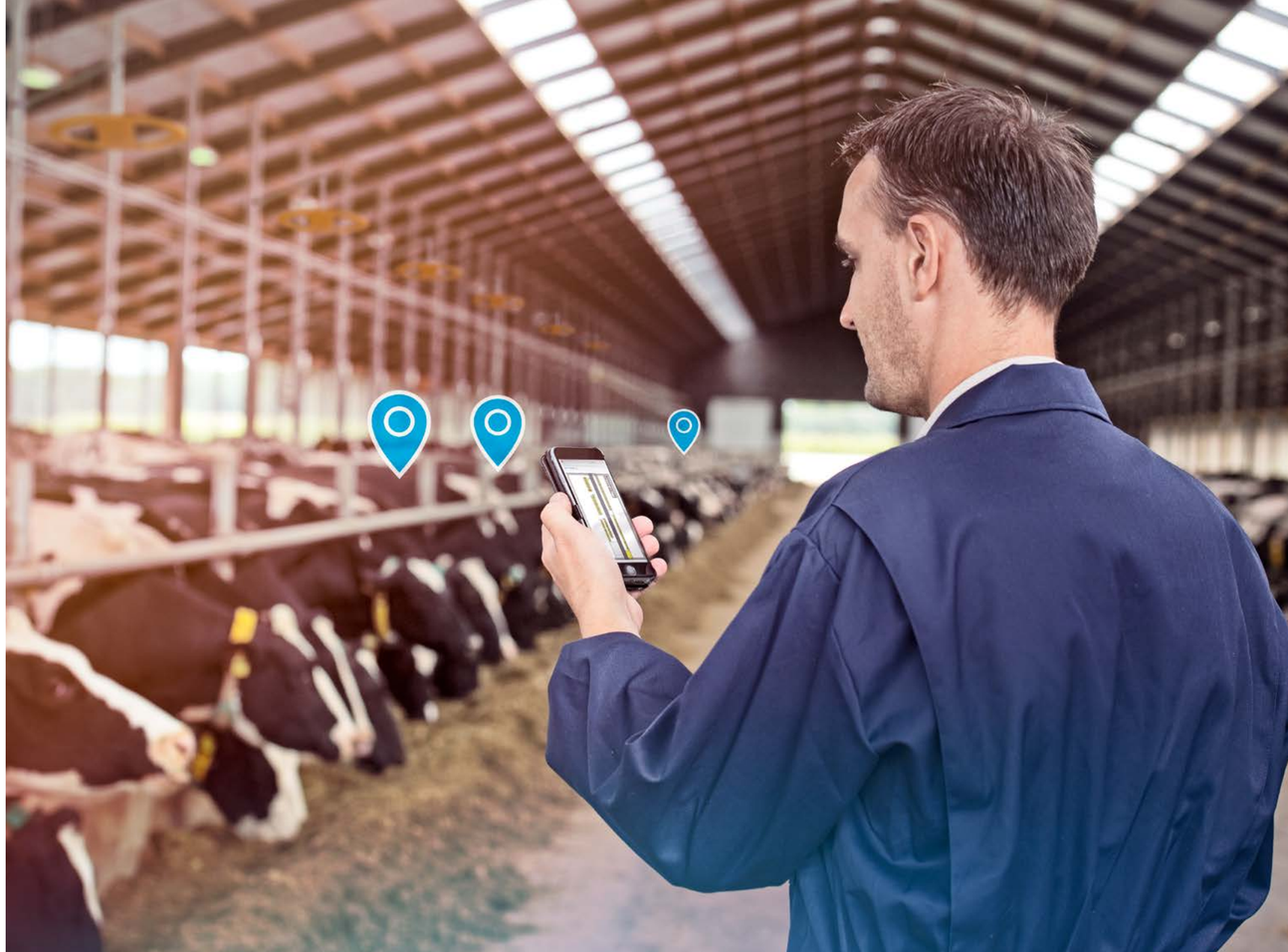


Figure 17: Protocol – A cow is the subject of an animal behavior alert. RATM score is attached on page 34.



Operational information regarding a group

The system provides operational information relating to individual cows and the group. An example of operational information on group level: a decrease in feed intake due to an employee failing to make the feed available or a decrease of eating and rumination because cows were locked at a feed bunk and standing for too long.

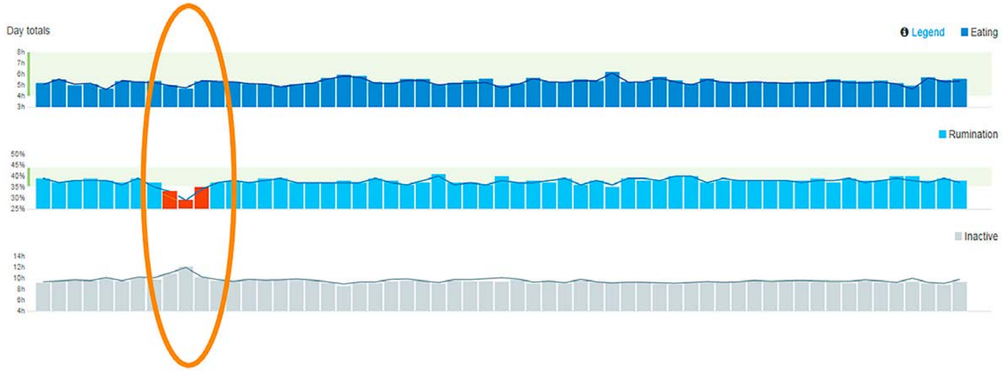


Figure 18: Example of a group overview showing a decrease in feed intake due to a mistake by an employee.

Tactical and strategic level

Cows form the backbone of every dairy farm. To achieve maximum production, it is important cows stay healthy. Not only does a behavior overview of a certain group or herd help the dairy farmer or herd manager to manage the barn, milking procedures and feeding processes, but it also provides information to configure the barn and walking routes of the cows. The various activities performed by the herd during the day, the average amount of time spent by cows for each activity and the variation of behavior amongst a group of cows are important factors that are enabling optimization to increase overall production and efficiency on a dairy farm.

Group monitoring

Stability and regularity are important contributions to the success of a dairy farm. Cows are creatures of habit and perform at their best if every day follows the same format. Any type of change in a cow's daily routine causes stress. Stress has a negative effect on milk production, reproduction and health of dairy cows. The amount of regularity due to a farm's management procedures can be determined by the behavior of a group of cows. The data generated by the Smarttag Neck provides insight into the behavior of a group of cows. Monitoring of eating, rumination and inactive behavior makes it possible to chart the herd's pattern. Feeding management measures are tactical measures. The dairy farmer or herd manager can monitor and evaluate the effects of feeding management measures by monitoring changes in eating, rumination and inactive behavior patterns at a group level.

Figure 19: Group Monitoring shows the day totals of the entire group. This empowers the farmer or herd manager with insights regarding - among others - availability of feed and water, TMR and TMR composition.

Group alerts

The Group Monitoring section of Nedap COWcontrol ™ alerts the dairy farmer or herd manager if a certain percentage of the cows on a farm is showing abnormal behavior when compared to their previous behavior. This alert indicates that external factors may be affecting behavior, posing a risk to milk production, reproduction and health of the cows.

Group / pen	Eating time	Rumination	Inactive	Reason
1. In lactation	6:14	34%	9:04	Decreased rumination: 19% of the animals

Figure 20: Group Monitoring alert.

Group Eating Pattern

Nedap COWcontrol ™ presents a unique 48-hour overview per group with the percentage of cows eating simultaneously.

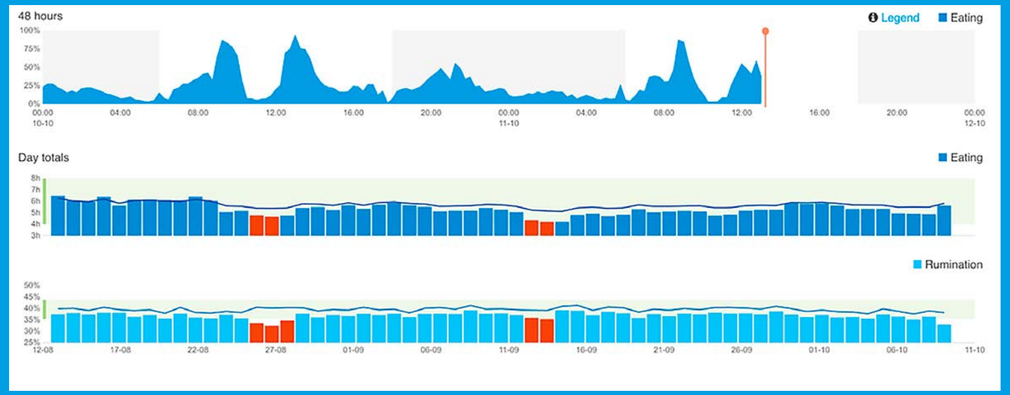


Figure 21: Group Eating Pattern and eating and rumination overview of a group of cows.

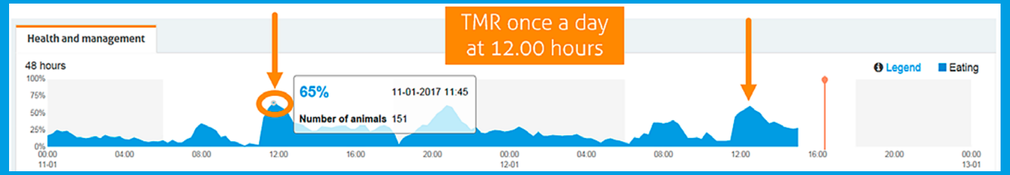


Figure 22: Example of Group Eating Pattern showing information about feeding moments, moments of pushing up the feed and feeding space availability.

Researchers used the information displayed in figures 21 and 22 to compare various (farm) procedures, such as:

- Forced and free movement of cattle.[16]
- Social unrest after regrouping or the introduction of new cows.

The routine of a group of dairy cows can be monitored by comparing information with reference values from research or by comparing group behavior on the farm. Charting and detecting changes or abnormalities provides dairy farmers or herd managers with a tool that enables him or her to respond and implement improvements if necessary according to the farm's management protocols.

Examples of tactical decisions

1. The data shows that 100% of the cows are not eating for four hours each day. The decision is made to provide feed on a more frequent basis.
2. The rumination time is too low throughout the entire herd. The solution is to improve the composition of the roughage.

Example of a strategic decision

The data shows that the cows are not eating simultaneously. The reason for this may be overcrowding of the barn or too few eating positions at the feed bunk. The solution is to create additional eating positions.

Annexes

Rumination, Activity, Temperature, Manure (RATM)

Rumen: fill

The rumen fill tells you whether the cow has eaten well during the past few hours.

Activity: cow is alert and active **Temperature: 38-38.5°C**

Eating and moving around with the other cows

Manure: lots, pasty, well digested

Pasty *Too thin* *Badly digested*

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