REMOTE MONITORING AND ANALYSIS OF INDOOR TEMPERATURE, DAIRY COWS' HEALTH AND PRODUCTIVITY IN LARGE LOOSE-HOUSING COWSHEDS BY AN AUTOMATIC NETWORK SYSTEM

Poikalainen, V.[1], Veermäe, I.[1], Praks, J.[1], Aland, A.[1], Kaart, T.[1], Kokin, E.[1], Pastell, M.[2], Ahokas, J.[2] and Hautala, M.[2]

[1] *Estonian University of Life Sciences, Kreutzwaldi 64, 51014 Tartu, Estonia;*
[2] *Department of Agrotechnology, P.O.Box 28, FI-00014 University of Helsinki, Finland*

SUMMARY

Some elements of health and welfare monitoring integrated automatic system have been developed and tested at large uninsulated loose housing cowsheds in Estonia. The paper describes preliminary results of these tests, in particular the analysis of relationships between animals' health, microclimate and productivity. It is possible to work out integral automatic health and welfare control system for dairy cattle as a part of precision livestock farming framework.

Keywords: dairy cow, precision livestock farming, microclimate, welfare, automation, health, lameness

OBJECTIVE

Objective of the study was to create and test an automatic network-connected data acquisition system for:

1) monitoring microclimate, health status and productivity of dairy cows in large uninsulated cowsheds;
2) determining relationships between these parameters.

METHODS

The outlines of automatic monitoring system of animal welfare parameters and it's testing in large farm

The main information sources at the dairy farm for animal welfare assessment are:

1. data received by the controllers of milking parlour or automated milking system central control unit (Alpro Windows, STRANGKO) – milk yield, milk quality, health status, and so on;
2. measurement results of inner climate parameters (temperature, humidity, illumination, gas content of the air) of the animal sheds and milking parlour;
3. corresponding weather data;
4. observation results of animal behaviour in the milking parlour and sheds;
5. measurements of weight changes of the animals;
6. measurements of leg load variations depending on the health status;

7. breathing frequency and heart rhythms measurements data;
8. body temperature measurements data of the animals;
9. health status assessment based on the observations, and so on.

The accessibility of the data depends mainly on the possibilities of measurements at the given farm and in case of complex solution the existence of local measurement system is needed. The measurement data is accessible both by the farm personnel and animal welfare researchers.

That is achieved by connecting all farm computers, including milking parlour central control server, into local network (LAN). Computers responsible for additional measurements compose local research network (RLAN). The server in RLAN, usually computer with MS Windows Server 2003 operation system, does the administration of both networks. Measurement devices and data-loggers are connected to the network through Ethernet-switches. As some of the systems are wireless, corresponding WiFi-routers are also needed.

For remote control, measurements and collected data transfer from different farms to animals' welfare researchers, every farm's LAN has to have an access to the Internet. The most suitable way for that is establishing persistent connection to some Internet service provider by the telephone line with ADSL-modem.

To access local network and Internet, research network server is equipped with two network cards – one for connection with local network switch and the other for connection with ADSL-modem. Server should be configured as router and remote access server.

For more secure data transfer from research network to remote users, including researchers in Estonian University of Life Sciences, Virtual Private Connection (VPN) should be used.

Another possibility to access research network server is Remote Desktop service, but in this case there should be active Transactions Server (in farm or in University local network) that issues licenses to Remote Desktop users.

The third way is to use Virtual Network Connection (Real VNC) software that in case of farm network enables remote researcher to use the resources of the RLAN server and to connect through it to other local computers without interrupting the work of local users (contrary to Remote Desktop).

VPN, Remote Desktop and VNC connections are needed only for farm's local network administration and measurements control. To monitor the results of the measurements and to copy data files to workstations in EULS network it is more convenient to use Web Server Services of RLAN server, creating farm's Internet-homepage with appropriate design.

The measurement devices at the farm may be grouped by their connectivity to the computers:

1. Devices that are controlled and from which data is received through local computer network. In our case that were data-logger WebDAQ/100 with Web-server functionality and video-cameras NC1000-W10, also with Web-servers. In addition to that Web-cameras are wireless.
2. Devices that transmit measurement data by radio channel to the receiver, connected to LAN computer by RS-232 or USB interface. To that group belong automatic wireless weather-stations La Crosse WS2305 and MicroLog data-loggers with temperature, air humidity and illumination sensors for microclimate parameters measurements.
3. Devices that are connected directly to LAN computer by RS-232 or USB interface. The typical device belonging to this group is data-logger Spyder that may be used for measurements of signals coming from dairy-cows leg load sensors (kvasipiezoelectric mat, tensoresistive scales).

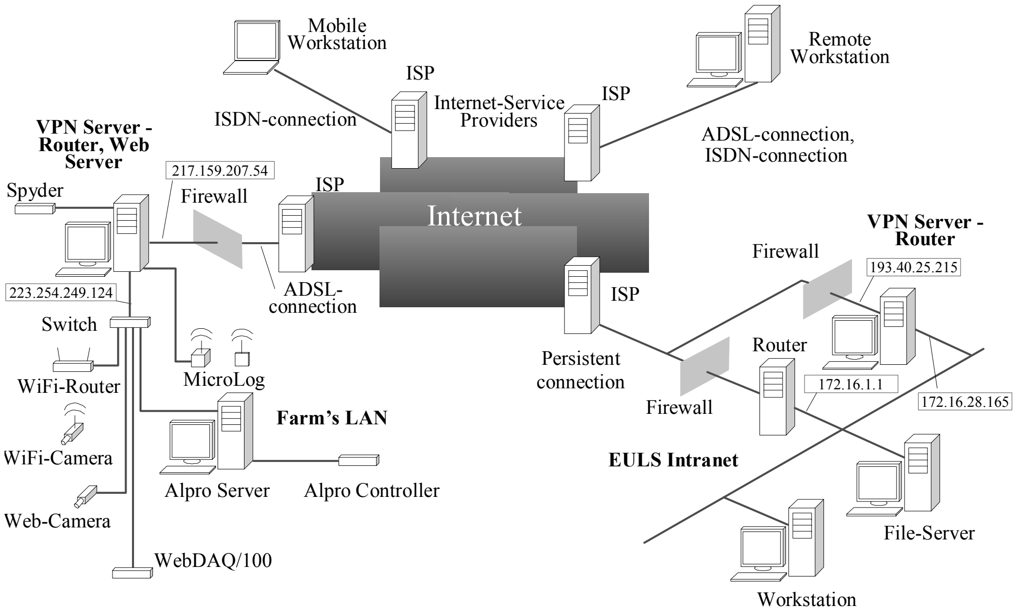

Figure 1. Farm's local network and Internet connectivity configuration

Figure 1 shows the configuration of farm's LAN, Internet-connection of this network and possibilities to access it from the EULS network and remote mobile workstations.

In case of such data-acquisition system structure all measurements results and data in milking parlour control system database are accessible through the farm's LAN and also to remote users in EULS network or elsewhere. To ensure appropriate level of security system servers should be equipped with firewall and virus protection software.

The first research network was created in summer of 2005 at AS Tartu Agro Vorbuse farm, where the milking parlour control system (DeLaval Alpro) database and backup files were copied regularly (once per day) to RLAN server. In 2006 automatic wireless weather station, video cameras and data-loggers for temperature, air relative humidity and illumination level measurements in sheds and milking parlour were added to the system. Measurements results and all other data are available at the farm's Internet homepage.

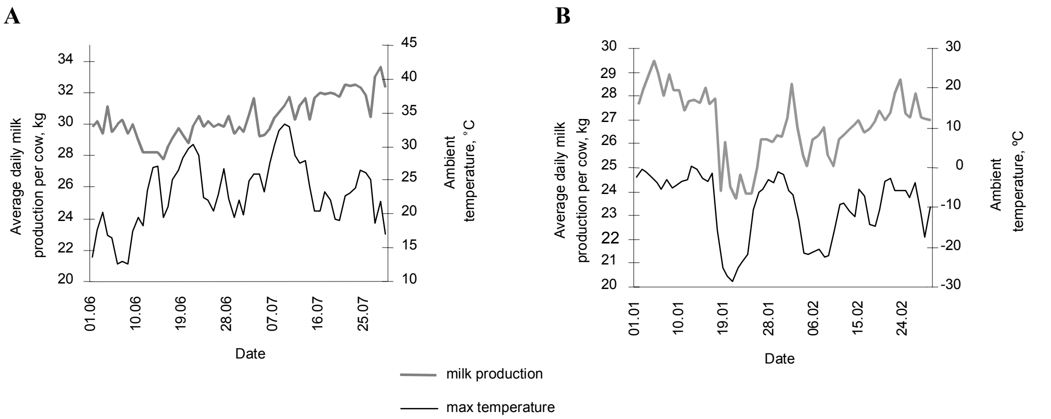

Figure 2. Relationships between ambient extreme temperatures and milk production per cow in summer (a) and winter (b)

At Pae Farmer farm and Torma POÜ farm automatic wireless weather stations and data-loggers for temperature, air relative humidity and illumination level measurements in sheds and milking parlours were installed.

At AS Estonia Kõrtsi farm the same measurement devices are used. In addition to that in December 2005 and January 2006 observations and video recordings of animals' behaviour during the process of customisation were made. The data received is not entirely analysed yet.

RESULTS

There were two extremely cold periods in January and February of 2006, when outdoor temperature dropped as low as –28.6 ºC. Cold periods lasted about a week each. In summer maximum temperature reached 33.3 ºC. Relationship between extreme outdoor temperatures and daily milk production per cow are given in Figure 2.

It appeared that during extremely cold period average daily milk production per cow dropped about 4 kg and remained low for a couple of days after the temperature had risen. The lower the outdoor temperature the bigger the decrease in milk production was. The same but in smaller scale appeared during hot period. This indicated the existence of thermal stress during these periods.

To study relationship between milk production and diseases of cows, milk production decrease of 20% was set as alarm level. The occurrence of diseases and corresponding number of low milk production alarms before diagnosis of disease are given in Table 1. The most frequent diseases were dyspepsia, mastitis, metabolic diseases and uterine infection. Corresponding decrease in milk yield was more evident in winter period and appeared in about 41% of cows with mastitis, 18% of cows with dyspepsia, 35% of cows with metabolic diseases and 11% of cows with uterine infection.

Table 1. Diseases and low milk production alarms in winter and summer

Disease	January-February			June-July		
	No of cases	No of alarms up to 6 days before	%	No of cases	No of alarms up to 6 days before	%
Abortion	1	1	100			
Abscess	2	1	50			
Dyspepsia	67	12	18	40	0	0
Enteritis	9	0	0	1	1	100
Exhaustion				16	6	38
Intoxication				1	0	0
Leg diseases	15	5	33	23	7	30
Mastitis	71	29	41	82	15	18
Metabolic diseases	54	19	35	12	3	25
Peritonitis				1	0	0
Respiratory diseases	21	0	0			
Rumen atony	6	5	83	2	1	50
Tetany				1	1	100
Trauma	1	0	0	8	1	13
Udder trauma	4	1	25	1	0	0
Uterine inflammation	45	5	11	42	3	7

It's evident that an association exists between climate conditions, productivity and cows' health. Based on the automatically registered climate and production data the changes preceding the disease can be recorded. Compared to the climate and production data corresponding to the healthy cows the relative risks and odds ratios as measures of the degree of association can be evaluated and their statistical significance tested. As the previous studies are showing the generalized linear models with logistic link function are suitable tools to model multifactor disease incidences. In future the changes in climate and production should be incorporated into a single complex model including also their interactions and possible confounding factors like cows' age and/or feeding. The adjusted relative risks calculated from the model coefficients express more precise and unbiased associations between climate conditions, productivity and disease incidences.

CONCLUSION

Automatic computer network systems can be used for monitoring of environment, health and production data of cows. The Internet access enables to analyse and evaluate relationships between these data remotely.

ACKNOWLEDGEMENTS

This project was funded by the Estonian Science Foundation (grants no. 5741, 5742, and 6053), projects Kartek and Ecostall. The authors are most grateful for the collaboration with the staff of the Vorbuse, Torma, Kortsi and Pae farms, who kindly allowed us to gather the data for this study.

REFERENCES

Allen, D.M., Linn, J.G. and Janni, K.A. 2003. Thermal Environmental Effects on Feed Intake in Commercial Dairy Herds. In: Proceedings of Fifth International Dairy Housing Conference. Worth, Texas. pp. 205–212.

Berman, A., Folman, Y.M., Kaim, M., Mamen, Z., Herz, D., Wolfenson, A. and Grabber, Y. 1985. Upper Critical Temperatures and Forced Ventilation Effects for High-yielding Dairy Cows in a Tropical Climate. Journal of Dairy Science 68 488–495.

Broucek J., Letkovicova M. and Kovalcuj K. 1991. Estimation of Cold Stress Effect on Dairy Cows. International Journal of Biometeorology 35(1) 29–32.

Frazzi, E. Calamari, L. and Calegari, F. 2003. Assessment of a Thermal Comfort Index to Estimate the Reduction of Milk Production Caused by Heat Stress in Dairy Cows Herds. In: Proceedings of the Fifth International Dairy Housing Conference. Fort Worth, Texas. pp. 269–276.

Hamada, T. 1971. Estimation of Lower Critical Temperatures for Dry and Lactating Dairy Cows. Journal of Dairy Science 54 1704–1705.

Berckmans D. Automatic On-line Monitoring of Animals by Precision Livestock Farming. In: Aniamal Production in Europe: The Way Forward in a Changing World.: Proceedings of in-between Congress of the ISAH, edited by F. Madec and G. Clement, 1 27–30

Krebs S., Danuser J., and Regula G. 2001. Using a Herd Health Monitoring System in the Assessment of Welfare. Acta Agric. Scand. 30 78–81.

Pastell, M., Takko, H., Gröhn, H., Hautala, M., Poikalainen, V., Praks, J.,Veermäe, I., Kujala M. and Ahokas J. 2006. Assessing Cows' Welfare: Weighing the cow in a milking robot. Biosysteems Engineering 93 (1) 81–87.

Pajumägi A., Veermäe I., Miljan J., Poikalainen V. and Praks J. 2003. The Microclimate of a Large Uninsulated Cowshed in an Extremely Cold Winter. In: Research for Rural Development 2003. International Scientific Conference Proceedings. Jelgava, Latvia. Pp. 119–124.

Poikalainen V., Veermäe I., Praks J., Aland A., Kokin E., Laikoja K., Ahokas J. and Hautala M. 2005. Possibilities of Automatic Assessment of Cows' Welfare. In: Animals and Environment. Proceedings of XIIth International Congress ISAH, Warsaw, Poland. Pp. 180–183.

Poikalainen, V., Ahokas, J., Praks, J., Hautala, M., Aland, A., Veermäe, I. 2004. Automatic Measurement System for Cows Leg Disorder Determination. In: Aniamal Production in Europe: The Way Forward in a Changing World. Proceedings of in-between Congress of the ISAH, edited by F. Madec and G. Clement Volume 1. Saint-Malo – France. pp. 123–124.

Spilke J. 2003. Decision Support under the Conditions of Automatic Milking Systems using Mixed Linear Models as Part of a Precision Dairy Farming Concept. EFITA 2003 conference, 5–9 July, Debrecen, Hungary. pp 780–785.

Veermäe I., Poikalainen V., Praks J. 2001. Cold Loose Housing of Dairy Cows in Estonia. In: Animal Welfare Considerations in Livestock Housing Systems. International Symposium of the 2nd Technical Section of International Commission of Agricultural Engineering. pp. 285–291.