Ukrainian Journal of Ecology

Ukrainian Journal of Ecology, 2021, 11(1), 325-328, doi: 10.15421/2021_49

ORIGINAL ARTICLE

Wind speed in easily assembled premises with different design constructions for side curtains in winter

O.O. Borshch[1], O.V. Borshch[1], O.I. Sobolev[1], V.M. Nadtochii[1], M.V. Slusar[2], B.V. Gutyj[2*], S.A. Polishchuk[1], V.V. Malina[1], A.P. Korol[1], L.P. Korol-Bezpala[1], I.F. Bezpalyi[1], O.O. Cherniavskyi[1]

[1] Bila Tserkva National Agrarian University, Bila Tserkva, Ukraine
[2] Polissia National University, Zhytomyr, Ukraine
[3] Stepan Gzhytskyi National University of Veterinary Medicine and Biotechnology, Lviv, Ukraine
**Corresponding author E-mail: bvh@ukr.net*
Received: 29.12.2020. Accepted 09.02.2021

This work aimed to identify the influence of the environment wind speed over similar indicators in easy-to-assemble premises of different configurations and insulation systems in the winter period. Air movement speed in the livestock room is also essential and affects animal and human bodies. At low temperatures in winter, a significant speed of air movement causes hypothermia in animals. High indoor wind speed can indicate the mistakes which had been made when choosing a farm location. The research was conducted in the central Forest-Steppe of Ukraine (Kyiv region) in three farms with free-stall housing of cows: option I – keeping in an easy-to-assemble room; option II – In an easy-to-assemble room with curtain insulation; option III – In an easy-to-assemble room on a deep straw litter within the period from December 1, 2019, to February 29, 2020. It has been established that the territory of the central part of Ukraine during the winter period of the year is characterized by the dominance of winds of the southern (South), south-eastern (South-East), and south-western (South-West) directions, which amount is more than 50% of average wind rose. The cold winds from the north and east constitute 31%. The average wind speed in winter is 9.8 m/s. The results of the research have shown that the use of insulation systems for side curtains can extend for 13 days the permissible norms of wind speed indoors and protect more effectively from the environment during all categories of wind speed, as well as reduce wind speed indoors by 11.68–21.74% compared to an easy-to-assemble box and deep litter.
Keywords: dairy cows, cold weather, wind speed, easy-to-assemble premises.

Introduction

The parameters of livestock premises microclimate as a component of the comfort housing conditions should best correspond to the biological characteristics of dairy cows and justified for them, depending on the methods of keeping, seasons, level of productivity, and the current standards (Angrecka & Herbut, 2016; Angrecka & Herbut, 2017; Borshch et al., 2017; Bomko et al., 2018; Kulyaba et al., 2019; Grymak et al., 2020; Mazur et al., 2020).

During breeds improving, a human tries to develop the animals' ability to convert the energy of food into milk and meat. An essential task in artificial animal environments for animals is to keep animals on the premises that protect them from the effects of adverse weather conditions (Ames & Insley, 1975; Broucek et al., 1991; Borshch et al., 2020).

Ambient temperature has the most significant effect on animals, on their thermal state, changing the course of vital processes. Thermoregulatory mechanisms allow animals to adapt to different temperature fluctuations of the environment and briefly tolerate significant air temperature deviations from their usual range (Brown-Brandl et al., 2005; Herbut, 2013). However, the magnitudes of heat regulation in the body are not unlimited, and after the violation of thermal balance, there is a change in the physiological state, disease resistance, and productivity of animals. Functional disorders in the body are possible due to both too high and too low air temperatures. Prolonged animals' exposure to high temperatures increases heart rate and respiration, increases sweat glands' activity, evaporates moisture, and reduces mobility, appetite, digestibility, feed nutrients intake, and productivity (Bergen et al., 2001; Borshch et al., 2019). Thus, with tie-up housing at 25 °C, the daily milk yield decreases by 17%, and at 30 °C – by 33%. Dairy cows lack heat in winter and transition seasons (Ruban et al., 2017).

Lowering the temperature in the room significantly increases the body's heat output. Animals try to reduce heat transfer; simultaneously, the pulse slows down, respiration deepens, and forage consumption increases (Pilatti & Vieira, 2017; Hempel et al., 2019). With the excessive and prolonged decrease in air temperature, animals' hypothermia occurs, and there are colds and other diseases at this background. If we take the daily milk yield for 100% at a temperature of 10 °C, then at minus 5 °C the milk loss constitutes 14%, and at minus 15–20 °C – the losses are even more significant.

The speed of air movement also affects the thermal balance of the animal's body. Its insignificant speed has a cooling effect and lowers the body temperature of animals. High airspeed at low humidity and high temperatures causes hypothermia and can lead to lung disease. In winter, frostbite cases are possible during the long-term stay of animals on feedlots at an air velocity of 5–7 m/s and air temperature even up to minus 20 °C (Ruban et al., 2020).

The speed of air movement in the livestock room is also essential and affects animal and human bodies. At high temperatures in summer, a significant air movement speed can positively affect the body, removing excess heat from the body, and in winter, on the contrary, it will cause hypothermia in animals. Therefore, the air velocity in the rooms for cows with free-stall housing and tie-up housing for cold and transition periods of 0.5 m/s is considered optimal, and for the summer period – 1.0 m/s. On the other hand, it is assumed that for dairy cows, regardless of the method of keeping in winter, the airspeed can be 0.3–0.4 m/s, during the transition period, it is 0.5 m/s, and in summer – 0.8–1.0 m/s. The Dutch guidelines state that for the comfort of dairy cows, the wind speed in cowsheds during the year should not exceed 0.7 m/s (Hulsen, 2013).

The ability of animals to adapt to thermal and cold irritants depends on the air humidity and animal movement speed in the room. High airspeed of more than 5–7 m/s outside the room in winter leads to frostbite of certain parts of the animal's body.

Our research aimed to identify the influence of environmental wind speed on similar indicators in easy-to-assemble rooms of different configurations and insulation systems in winter.

Materials and Methods

The researches were conducted in the central Forest-Steppe of Ukraine (Kyiv region) in three farms with free-stall housing of cows: option I - keeping in an easy-to-assemble room (49° 51' 27" N, 30° 6' 36" E); option II – in an easy-to-assemble room with curtain insulation (49° 52' 28" N, 30° 5' 12" E); option III - in an easy-to-assemble room on a deep straw litter (49° 34' 56" N, 30° 38' 10" E) during the period from December 1, 2019, to February 29, 2020.

The average daily wind speed and its direction were determined according to the Kyiv Center for Hydrometeorology. The barn's wind speed was determined by handheld pocket digital anemometer AZ, model AZ-8919 (Taiwan).

The obtained data were statistically processed using STATISTICA (Version 11.0, 2012) software. The Student's *t*-test was used to estimate the statistical significance of the obtained values. Data were considered significant at $P < 0.05$, $P < 0.01$, $P < 0.001$.

Results and Discussion

Among the weather factors that affect cows' comfort and well-being during different times of year is the wind speed. In winter, at negative temperatures, gusts of wind can lower the air masses' temperature, which affects the productivity, energy status, and behavior of animals. This indicator is significant for keeping cows in easy-to-assemble premises in winter because side ventilation curtains, usually made of polycarbonate or polyvinyl chloride, are less cold and wind resistant than brick walls in capital-type buildings. The design features of the research premises are given in the table.

Table 1. Structural features of the premises that characterize the maintenance comfort

Type of a room and option of keeping	Room parameters LxWxH, m	Height of longitudinal walls, m	Width of light-aeration ridge, m
Easy to assemble:			
- boxes	150x34x10.5	0.9	2.1
- boxes with elements of heating	150x34x10.5	0.9	2.1
- on a deep litter	100x60x10	0.8	0.7

The territory of the central part of Ukraine during the winter period of the year is characterized by the dominance of winds of the southern (South), south-eastern (South-East), and south-western (South-West) directions, which together constitute more than 50% of the average rose-winds (Table). The cold winds from the north and east constitute 31%. The average wind speed in winter is 9.8 m/s. We observed the highest winds in the North and East directions in January and the highest average wind speed among the winter months.

Table 2. The average wind rose (%) and wind speed (m/s) during winter months for the central Forest-Steppe territory of Ukraine

Months	The direction of the wind								Calm	The average speed of the wind movement
	North.	North East	East.	South East.	South	South West.	West	North West		
December	7	8	8	12	28	17	12	8	4	8,8
January	9	6	7	11	25	16	15	11	5	10,4
February	9	5	7	11	26	15	16	10	5	9,7

We established that among the studied variants for keeping cows in easy-to-assemble premises, the limit of the critical value of wind speed (0.7 m) in easy-to-assemble rooms with boxing and deep litter is the wind speed of the environment up to 20 m/s (Table). Under such conditions, these values are 0.82 and 0.81 m/s, respectively. During boxing keeping with insulation

elements, the room's critical wind speed was at a wind speed of 25 m/s and constituted – 0.83 m/s. In general, the use of insulation systems for side curtains can extend for 13 days the permissible norms of wind speed indoors and more effectively protects against environmental influences during all categories of wind speed, as well as reduces wind speed indoors by 11.68–21.74% compared to prefabricated boxed rooms and rooms with deep litter.

Table 3. Wind speed in premises with different construction design options for side curtains during the winter period, m/s

Categories of the environment wind speed m/s	Quantity of dates	A variant of keeping in an easy-to-assemble room		
		Boxes	Boxes with the elements of heating	On the deep litter
> 30	4	1,03±0,03	0,92±0,02	1,01±0,03
25	8	0,94±0,02*	0,83±0,02*	0,93±0,02
20	13	0,82±0,02**	0,70±0,02**	0,81±0,02***
15	14	0,70±0,02***	0,61±0,02**	0,69±0,02***
10	20	0,60±0,02**	0,48±0,02***	0,60±0,02**
< 5	31	0,46±0,03***	0,36±0,02***	0,44±0,03***

Notes:*P<0.05; **P<0.01; ***P<0.001 as compared with the next higher category of wind speed

Conclusions

The results of the research show that the use of side curtain insulation systems can extend for 13 days the permissible norms of wind speed indoors and protect more effectively against environmental influences during all categories of wind speed, as well as reduce wind speed indoors by 11.68–21.74% compared to prefabricated box rooms and rooms with deep litter.

References

Ames, D.R., & Insley, L.W. (1975). Wind-chill effect for cattle and sheep. Journal of Animal Science, 40, 161–165. doi: 10.2527/jas1975.401161x.

Angrecka, S., & Herbut, P. (2016). Impact of Barn Orientation on Insolation and Temperature of Stalls Surface. Annals of Animal Science, 16 (3), 887–896. doi: 10.1515/aoas-2015-0096.

Angrecka, S., & Herbut, P. (2017). Eligibility of lying boxes at different THI levels in a freestall barn. Annals of Animal Science, 17, 257–269. doi: 10.1515/aoas-2016-0053.

Bergen, R.D., Kennedy, A.D., & Christopherson, R.J. (2001). Effects of intermittent cold exposure varying in intensity on core body temperature and resting heat production of beef cattle. Canadian Journal of Animal Science, 81, 459–465.

Bomko, V., Kropyvka, Yu., Bomko, L., Chernyuk, S., Kropyvka, S., & Gutyj, B. (2018). Effect of mixed ligand complexes of Zinc, Manganese, and Cobalt on the Manganese balance in high-yielding cows during first 100-days lactation. Ukrainian Journal of Ecology, 8(1), 420–425. doi: 10.15421/2018_230.

Borshch, A.A., Ruban, S., Borshch, A.V., & Babenko, O.I. (2019). Effect of three bedding materials on the microclimate conditions, cows behavior and milk yield. Polish Journal of Natural Sciences, 34 (1), 19–31.

Borshch, O.O., Borshch, O.V., Donchenko, T.A., Kosior, L.T., & Pirova, L.V. (2017). Influence of low temperatures on behavior, productivity and bioenergy parameters of dairy cows kept in cubicle stalls and deep litter system. Ukrainian Journal of Ecology, 7(3), 73–77. doi: 10.15421/2017_51.

Borshch, O.O., Gutyj, B.V., Sobolev, O.I., Borshch, O.V., Ruban, S.Yu., Bilkevich, V.V., Dutka, V.R., Chernenko, O. M., Zhelavskyi, M. M., & Nahirniak, T. (2020). Adaptation strategy of different cow genotypes to the voluntary milking system. Ukrainian Journal of Ecology, 10(1), 145-150. doi: 10.15421/2020_23.

Borshch, O.O., Ruban, S.Yu., Gutyj, B.V., Borshch, O.V., Sobolev, O.I., Kosior, L.T., Fedorchenko, M.M., Kirii, A.A., Pivtorak, Y.I., Salamakha, I.Yu., Hordiichuk, N.M., Hordiichuk, L.M., Kamratska, O.I., & Denkovich, B.S. (2020). Comfort and cow behavior during periods of intense precipitation. Ukrainian Journal of Ecology, 10(6), 98-102. doi: 10.15421/2020_265.

Broucek, J., Letkovicova, M., & Kovalcuj, K. (1991). Estimation of cold stress effect on dairy cows. International Journal of Biometeorology, 35, 29–32. doi: 10.1007/BF01040960.

Brown-Brandl, T.M., Eigenberg, R.A., Nienaber, J.A., & Hahn, J.L. (2005). Dynamic response indicators of heat stress in shaded and non-shaded feedlot cattle, part 1: analysis of indicators. Biosystems Engineering, 91(4), 451-462. doi: 10.1016/j.biosystemseng.2004.12.006.

Grymak, Y., Skoromna, O., Stadnytska, O., Sobolev, O., Gutyj, B., Shalovylo, S., Hachak, Y., Grabovska, O., Bushueva, I., Denys, G., Hudyma, V., Pakholkiv, N., Jarochovich, I., Nahirniak, T., Pavliv, O., Farionik, T., & Bratyuk, V. (2020). Influence of "Thireomagnile" and "Thyrioton" preparations on the antioxidant status of pregnant cows. Ukrainian Journal of Ecology, 10(1), 122-126. doi: 10.15421/2020_19.

Hempel, S., Menz, C., Pinto, S., Galán, E., Janke, D., Estellés, F., Müschner-Siemens, T., Wang, X., Heinicke, J., Zhang, G., Amon, B., Del Prado, A., & Amon, T. (2019). Heat stress risk in European dairy cattle husbandry under different climate change scenarios – uncertainties and potential impacts. Earth System Dynamics, 10, 859–884. doi: 10.5194/esd-10-859-2019.

Herbut, P. (2013). Temperature, humidity and air movement variations inside a free-stall barn during heavy frost. Annals of Animal Science, 13(3), 587–596. doi: 10.2478/aoas-2013-0025.

Hulsen, J. (2013). Cow signals a practical guide for Dairy Farm Management, UK/Ireland edition, 95 p.

Kulyaba, O., Stybel, V., Gutyj, B., Turko, I., Peleno, R., Turko, Ya., Golovach, P., Vishchur, V., Prijma, O., Mazur, I., Dutka, V., Todoriuk, V., Golub, O. Dmytriv, O., & Oseredchuk, R. (2019). Effect of experimental fascioliasis on the protein synthesis function of cow liver. Ukrainian Journal of Ecology, 9(4), 612-615.

Mazur, N.P., Fedorovych, V.V., Fedorovych, E.I., Fedorovych, O.V., Bodnar, P.V., Gutyj, B.V., Kuziv, M.I., Kuziv, N.M., Orikhivskyi, T.V., Grabovska, O.S., Denys, H.H., Stakhiv, N.P., Hudyma, V.Yu., & Pakholkiv, N.I. (2020). Effect of morphological and biochemical blood composition on milk yield in Simmental breed cows of different production types. Ukrainian Journal of Ecology, 10(2), 61-67.doi: 10.15421/2020_110.

Pilatti, J.A., & Vieira, F.M. (2017). Environment, behavior and welfare aspects of dairy cows reared in compost bedded pack barns system. Journal of Animal Behavior and Biometeorology, 5, 97–105. doi: 10.14269/2318-1265/JABB.V5N3P97-105.

Ruban, S., Borshch, O.O., Borshch, O.V., Orischuk, O., Balatskiy, Y., Fedorchenko, M., Kachan, A., & Zlochevskiy, M. (2020). The impact of high temperatures on respiration rate, breathing condition and productivity of dairy cows in different production systems. Animal Science Papers and Reports, 38(l), 61–72.

Ruban, S.Yu., Borshch, O.V., & Borshch, O.O. (2017). Suchasni tekhnolohiyi vyrobnytstva moloka. (osoblyvosti ekspluatatsiyi, tekhnolohichni rishennya, eskizni proekty) [Modern milk production technologies. (peculiarities of operation, technological decisions, sketch designs)]. Kharkiv: STYLIZDAT (in Ukrainian).

Citation:

Borshch, O.O., Borshch, O.V., Sobolev, O.I., Nadtochii, V.M., Slusar, M.V., Gutyj, B.V., Polishchuk, S.A., Malina, V.V., Korol, A.P., Korol-Bezpala, L.P., Bezpalyi, I.F., Cherniavskyi, O.O. (2021). Wind speed in easily assembled premises with different design constructions for side curtains in winter. *Ukrainian Journal of Ecology, 11* (1), 325-328.