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The Effect of New Designed Micro Animal Housing on the Air Speed Distribution in the Barn for Providing of Climatic Comfort to the Cattles

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Abstract: In the research, a new animal housing was designed and built in Konya, Turkey. In the new design for the open loose system of beef and of milk cattle, the structural stress was decreased for the animals by planning new areas, in which they can use during different seasons. The air speed distributions inside the shelter were analyzed in the building for obtaining climatic comfort. According to the research results, when the wind came perpendicularly, diagonally and with 90° angle to the barn, the following inside air speeds of 0.07, 0.53 and 0.39 m sec^{-1} were obtained for outside speeds of 2.81, 4.18 and 2.41 m sec^{-1}, respectively. The wind speed was decreased between 85-97% in new designed housing system.

Key words: Barn design, wind speed, climatic condition, animal housing, heat stress, cold stress

INTRODUCTION

In livestock farming, the sheltering conditions have to be suitable in order for the production to be increased. In order for barn and sheltering conditions to be suitable, the animal has to be kept in a stress free environment. The primary stress causing elements are caused by climatic, structural and social factors. The most important factors in the climatic stress are temperature, air speed, radiation and relative humidity. High productivity in animals can only be obtained by keeping them in healthy and comfortable sheltering environments. The animals that live in stress free environments will have stronger immune systems and they will have a lesser chance of getting ill. In order for them to continue their living quality conditions, there will also be lesser medical treatment sports. In continuous livestock farming, the shelter design is the most elemental factor, for obtaining maximum animal comfort and for obtaining quality living conditions. Building design has an important function in creating proper climate conditions in the animal barns. Air speed is an important consideration in the comfort of the animals. The effect of the air speed on the animal, changes according to the seasons. The main mechanism of obtaining climate comfort in animals depends on whether the animal's heat production and heat loss can be balanced easily. All climate factors affect the animal's heat production and loss mechanism and dependent on its degree of influence and form; a comfortable or stressful environment can be formed.

Animals emit the heat energy that they produce as sensible heat (convection, conduction, radiation) and as latent heat (evaporative heat loss from body surface and respiratory system). The air speed will multiply the convectional heat emission of animals. Due to the high air speed, the animal's total heat emission will increase by high heat emission of convection. When the air speed is high in cold seasons, this will cause cold stress, since it will force the animal to negative heat balance.

The effective temperature that the animal feels will be lowered due to high air speed in low temperatures. The animal will lose heat, just as if it is living in a lower temperature instead of the current temperature (Bryant *et al*., 2007). In conditions, where the animals' body surface is dry, when the air temperature is -1°C and when air speed is 6.5 m sec^{-1}, then the effective temperature that is felt becomes -10°C (Tarr, 2007). For milk cows, the critical low temperature of draught free air and dry surface conditions is given as -22°C, while for 4 m sec^{-1} air speed and for 30% wetting conditions in body surface, the critical low temperature is given as -1°C by Charles (1994).

But in hot periods, the heat loss of animal body by convection, radiation and conduction becomes insufficient. Thus, in these periods, the animal will obtain body heat balance by developing extra heat loss by evaporation. Generally, animals emit latent heat loss in hot periods by increasing their respiration rate as compared to their normal respiratory rate. In this period, since the high air speed will increase by convection heat loss, this will

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decrease the heat stress by having a positive effect on the heat balance of the animal. In this research, new building model were developed for climatic and structural animal comfort and alternative sheltering system were built in Konya, Turkey.

MATERIALS AND METHODS

In the research, the alternative open loose animal housing was designed by Ugurlu and Uzal (2007) and new barn model for cattle were built in Konya, Turkey. In the new designed housing model, large and different areas were proved for animals in use of different season. The stocking density for adult cattle were recommended as 6-8 m^2/animal resting, 20-30 m^2/animal yard area and 1.0 m/animal feeding length. The perspective and plan view of new designed animal housing were given in Fig. 1 and 2. The main purpose of research was to form a stress free environment for the animals. In the system, different building areas were planned for lessening the climatic, structural and social stress. However, small (micro) structures were placed on the two sides of the main building groups for the forming of draught free condition in resting areas and in frontal courtyard.

In this study, the air speed was measured outside and inside of the building at same time in 4 different points. Air speed distribution in the barn was determined according to the 8 different directions from which the wind came to the building (Fig. 2). In the research, the inside air speed distribution were determined for wind that

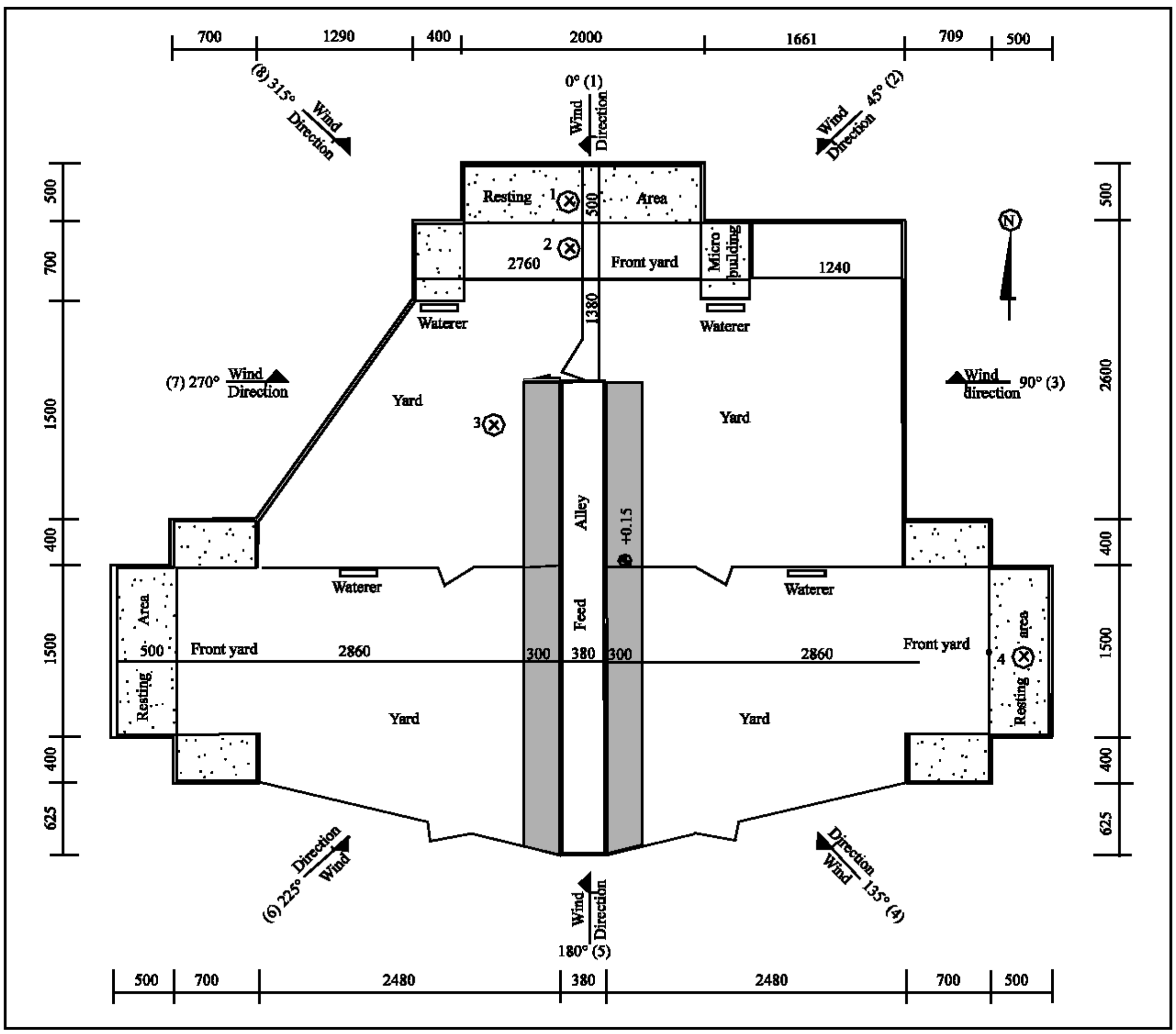

Fig. 1: Plan view of new designed barn and air speed measurement points by wind direction (cm)

Table 1: The average air speed distribution in barn areas for different wind direction

			Air speed measurement points in barn			
Wind direction	Measurement location	Air speed	I	II	III	IV
(350-10)	Outside	Wind speed (m sec^{-1})	2.81	5.83	4.72	4.94
	Inside	Air speed (m sec^{-1})	0.07	0.48	1.71	0.78
		Reduction of wind (%)	97	91	64	85
(35-55)	Outside	Wind speed (m sec^{-1})	4.18	2.44	4.59	5.68
	Inside	Air speed (m sec^{-1})	0.53	0.35	2.53	0.55
		Reduction of wind (%)	87	86	45	90
(80-100)	Outside	Wind speed (m sec^{-1})	2.41	1.28	2.74	2.69
	Inside	Air speed (m sec^{-1})	0.39	0.26	0.90	0.17
		Reduction of wind (%)	84	80	67	94
(125-145)	Outside	Wind speed (m sec^{-1})	1.11	0.57	1.56	0.87
	Inside	Air speed (m sec^{-1})	0.15	0.29	1.11	0.11
		Reduction of wind (%)	86	49	29	87
(170-190)	Outside	Wind speed (m sec^{-1})	2.15	2.16	2.72	0.96
	Inside	Air speed (m sec^{-1})	0.55	1.49	2.08	0.34
		Reduction of wind (%)	74	31	24	65
(215-235)	Outside	Wind speed (m sec^{-1})	0.76	1.59	1.73	0.97
	Inside	Air speed (m sec^{-1})	0.12	0.49	1.48	0.26
		Reduction of wind (%)	84	69	14	73
(260-280)	Outside	Wind speed (m sec^{-1})	1.06	1.69	1.93	2.40
	Inside	Air speed (m sec^{-1})	0.14	0.10	0.79	0.27
		Reduction of wind (%)	87	94	59	89
(305-325)	Outside	Wind speed (m sec^{-1})	1.19	3.66	3.66	4.01
	Inside	Air speed (m sec^{-1})	0.05	0.33	1.98	1.18
		Reduction of wind (%)	96	91	46	71

Fig. 2: Perspective view of new designed micro animal housing

comes to the animal housing from different speeds and directions. For this purpose, two small weather stations (Hobo weather station) were used. With the weather station that was installed on the inside and outside of the shelter, the data relating to air speed and direction was continuously recorded. In the shelter, measurements were made in different points at height related to animal levels, for the outer wind speed values, which formed inside. The weather station memory is 512 KB and air speed sensor measurement range is 0.44 m sec^{-1}, resolution is 0.19 m sec^{-1} and accuracy is ±3%. In climatic measurements, the data was recorded with 10 min intervals. Between 5000-12000 air speed values were analyzed in each points for a total of 33,000 values at each 4 points. The research was carried out for a year.

RESULTS AND DISCUSSION

The air speed measurement values distribution for the open loose micro animal housing system, with the design model and plan in Fig. 1 and 2, were given in Table 1. In the research, for the 8 different locations at which the wind came, the air speed distributions were obtained at resting area, frontal yard and at walking areas. When the wind came perpendicular to the main building, the average wind speed outside of the shelter is 2.8 m sec^{-1}, while the average air speed in the resting area was found as 0.07 m sec^{-1}.

This data was obtained by analyzing about 6900 different data. For a 2.8 m sec^{-1} of air speed in the outside environment, draught free area was occurred in the interior area. The decrease rate in the wind speed was found as 97% (Table 1).

In this sheltering system that was designed, wide and different areas were planned, which offer stress free natural environment to the animals. In the research, the concept of resting areas and the draught free area in the frontal yard was strengthened for obtaining climatic comfort of the animal by decreasing the heat loss caused by convection in cold periods. The primary animal building groups were targeted to have stagnant air flow, in which the wind came perpendicularly, diagonally (45°) and with 90° angle. But in open areas, in opposite of the statement made above, the air speed is wanted to be a little higher, in order to increase the heat loss by convection in the hot periods, for helping to cool the animal and for helping to balance their body heat.

Just like it was shown in Table 1, when the wind arrived perpendicularly, diagonally and with 90° angle to the I. position; the decrease in the outer wind speed was found as 97, 87 and 84%, respectively.

The air speed formed in the frontal yard was 0.48 m sec^{-1} for the average outside wind speed of 5.85 m sec^{-1}. In the II position (frontal yard), where the wind came perpendicularly, diagonally and with 90° to the building, the air speeds were an average of 0.48, 0.35 and 0.26 m sec^{-1} and the decrease rate in the air speeds were obtained respectively as 91, 86 and 80%. Similarly, at position IV, same data were found. The lower temperature, wind; snow and mud increased winter stress in open livestock farming and also caused animal losses. The high wind speed (5 m sec^{-1}) in low temperatures along with worse sheltering conditions (wet ground), were caused important losses in the daily weight gain of the beef cattle (Britt , 2007). Generally, the air speed was around 0.5 m sec^{-1} for low temperatures (McArthur, 1981; Charles, 1994; Ugurlu and Uzal, 2009).

In a result, in new design type, effective decrease in the air speeds was provided in the resting areas and in the frontal yard that were mostly used by animals for mainly resting in the cold seasons.

The increase of climatic comfort and the decrease of cold stress in animals were attained important results. In open areas, in conditions where the wind came perpendicularly, diagonally and with 90° angle to the building; there was a 45-67% decrease in the air speed. Chase (2005) stated that many of new facilities being built include housing components to minimize effect of heat stress. Especially, the summer months when the area slowly is draught, contribute to a decrease in the heat stress that help the animals to cooler by increasing their convectional heat loss.

CONCLUSION

The new cattle housing model were developed to providing more comfortable building area aspect of air low. The inside air speed were decreased 97-80% in resting and front yard area that used commonly by animal in winter season. The climatic, structural and social stress can be alleviating by design of alternative housing model that offered suitable barn areas for animals.

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