KAPITEL 6 / *CHAPTER 6* [6]
WAYS TO SOLVE ANIMAL WELFARE IN THE CONTEXT OF CLIMATE CHANGE IN THE SOUTHERN REGION OF UKRAINE

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Introduction.

Nowadays, humanity is increasingly concerned about global climate change: in the last quarter of the 20th century, there was rapid warming. The number of very cold winters has significantly decreased, and the average temperature of the Earth's surface has increased by 0.7°C. The climate has changed naturally for millions of years. However, today it is changing even faster [1]. It is important to remember that global climate change can have dangerous consequences for all of humanity. Is also known that climate has a significant impact on flora and fauna, soils and water systems. A lot of problems in animal husbandry are related to weather and climate. To reduce climate risks in animal husbandry, it is necessary to understand both potential environmental stressors (temperature, humidity, thermal radiation and wind speed) directly affect the functions of the animals' body, their health and the realization of their genetic potential. Weather and climatic conditions are important factors in the correct choice of technologies for breeding and keeping livestock, the organization and improvement of livestock farms and complexes, in general, to ensure the welfare of animals.

The well-being of animals most often depends on their ability to adapt and develop in a harmonious relationship with the environment, ensuring both physical and psychological well-being. Over the years, the issue of farm animal welfare has attracted worldwide attention and has become increasingly important to the general public and academia. The link between the environment and animal welfare is primarily established through the provision of an appropriate and controlled environment for animals. However, it is important to recognize that environmental influences go beyond simply providing freedom from discomfort.

The environment plays a crucial role in shaping an animal's response to problems

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such as disease, stress, and pathogens. While animals can be kept in a controlled environment that provides optimal conditions for health, performance, and well-being, it is important to recognize that specific scenarios can significantly impact and alter environmental requirements. Even with access to fresh air, certain factors can significantly affect the well-being of animals. Moreover, providing suitable environmental conditions goes beyond meeting basic needs and can greatly contribute to ensuring that animals can lead their natural lifestyles. It is an important tool for ensuring and maintaining adequate standards of well-being.

In recent years, in the context of a number of political upheavals, the concept of welfare of farm animals has gained great importance and attracted increased attention both from the general public and from the scientific community [2, 3].

Ensuring animal welfare is an ethical responsibility. Covers the physical and mental state of animals, taking into account their health, behavior and biological functioning. Environmental conditions play a crucial role in animal welfare, whereas providing the right conditions allows animals to fully express their natural behavior. Therefore, the well-being of animals depends on their ability to adapt and coexist harmoniously with the environment, thus providing support for both physical and psychological well-being.

Main text. Critical environmental factors, including air temperature, relative humidity, and air quality, are vital to ensuring animal welfare, maximizing productivity, and optimizing feed use. By providing a comfortable environment, health and well-being in industrial husbandry environments can be significantly improved.

Taking into account climatic conditions, scientists and livestock breeders are developing ways to reduce the impact of heat stress on the productivity of cows on the farm. Various methods, such as technological advances and potential changes in housing systems, can increase the welfare of farm animals.

The territory of livestock enterprises must be properly landscaped, which ensures its proper sanitary condition. Pedestrian paths for service personnel, roads for the passage of vehicles, as well as walking areas must have a hard surface (asphalt, concrete). Landscaping should be provided in areas free of development, which do not

have a hard surface, as well as around the entire perimeter of the farm. Green spaces, acting as biological filters, should occupy at least 10-15% of the farm territory.

In the summer months in the zone of green spaces, the air temperature during the day is lower by 2-3ºC, and on some days this difference reaches 10-13ºC, the relative humidity in areas protected by plantations increases by an average of 8%, and on some days - by 42% compared to the open area. An increase in humidity in the green area occurs due to the moisture of the leaves, which evaporates. Plantings show a noticeable effect on air humidity at a distance of 10-12 times, which exceeds their height.

Planting trees and shrubs reduces wind pressure. On the leeward side, the air speed is reduced by 70-80%. At the same time, they are a powerful tool that improves air purity, retaining from 50 to 73% of dust and reducing the number of microorganisms by 25-50%. So, poplar alone precipitates up to 53 kg of dust during the growing season. In addition, green spaces have a great deodorizing ability - they retain and absorb gases. Landscaping the farm around the perimeter of the territory during the cold period protects it from snowdrift. Has been established a positive effect of green spaces on physiological indicators (heat regulation, oxidative processes) and animal productivity.

Unfavorable environmental conditions often cause thermal stress to animals, which leads to a decrease in productive performance, an increase in morbidity and mortality rates and, as a result, economic losses, all of which relate to animal welfare.

In addition to the lack of precipitation, direct and prolonged solar exposure, together with high temperatures, affect not only plants, but also animals. The situation in the last years of the summer period of 2021 - 2023, according to synoptic observations in the Kherson region (Table 1), indicates the expectation of an increase in temperatures in the future, which may most likely lead to even more intense and prolonged periods of heat and, accordingly, loss of production.

Table 1 Temperature of the hottest months of summer in the Kherson region

Year	July (°C)	August (°C)
2021	24,5	23,8
2022	24,0	23,5
2023	25,2	24,1

These data show that temperatures in these months have been increasing year after

year, with particularly high rates in July 2023, when the average daily temperature reached 25.2°C.

When studying the influence of thermal stress factors on the milk productivity of cows in the State Enterprise "Experimental Farm "Askaniyske", it was found that heat stress depends on or is caused not only by ambient temperature, but also relative humidity. The collection of data on air temperature and relative humidity in the barn, on the walking area, under the canopies of the walking area and in the shade of trees on the farm made it possible to analyze the influence of weather and microclimate on the health of animals and their productivity (Figure 1).

The most unfavorable area for keeping cows turned out to be walking areas, where even sheds did not save animals from moderate heat stress, animals that were on the walking area during the day were subjected to moderate heat stress (THI > 72).

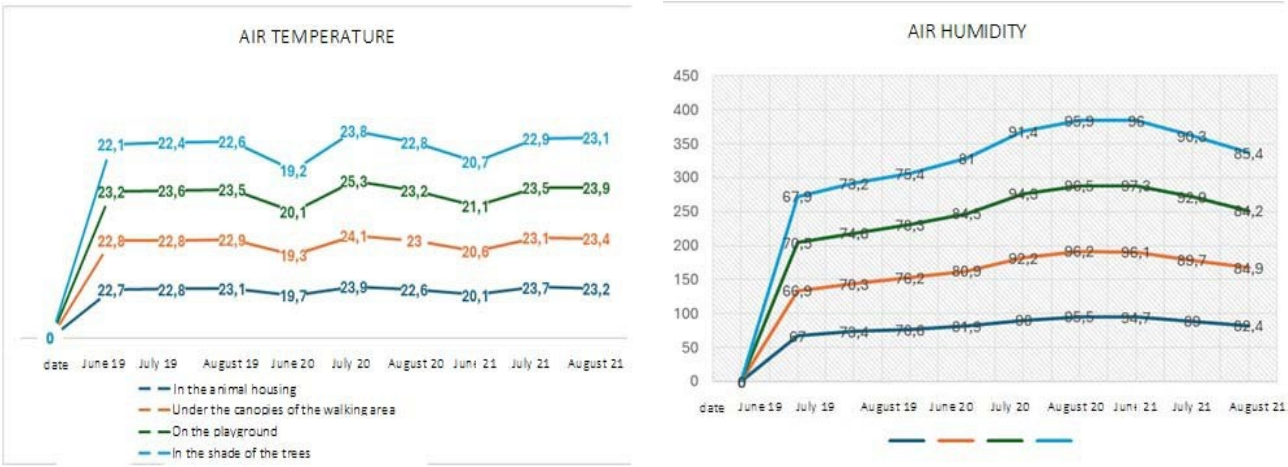

Figure 1. Temperature and humidity data in different zones on the farm

The conditions for keeping cows in the barn were more comfortable, but at high temperatures there were also deviations in the direction of negative consequences, namely the possibility of obtaining heat stress TNI (72 and 75), which leads to a loss of productivity by animals. Due to weather conditions, the microclimate parameters in the cow housing room did not correspond to zoohygienic conditions and at the end of the month approached a critical limit even with the fans on. TNI indicators in the shade of trees on the farm were the most favorable for keeping animals and did not exceed critical TNI indicators. Even in hot weather, the TNI indicator did not exceed the threshold value for the occurrence of heat stress in cows (Figure 2).

Heat stress problems are crucial in regions characterized by hot and humid climates. This combination negatively affects the reproductive performance of cattle, the course of pregnancy and the functional state of newborn calves [4]. As noted by a number of researchers, the signs and symptoms of heat stress in cows are a decrease in feed intake and a decrease in milk yield, increased respiratory rate, an increase in body temperature and a decrease in overall reproductive Functions.

There are other problems, for example, a seasonal increase in the number of somatic cells in a volumetric tank. Birth weight decreases in cows that have been subjected to heat stress throughout the dry period. It has been established that the most critical is the heat accumulated by direct radiation from solar energy [5, 6, 7].

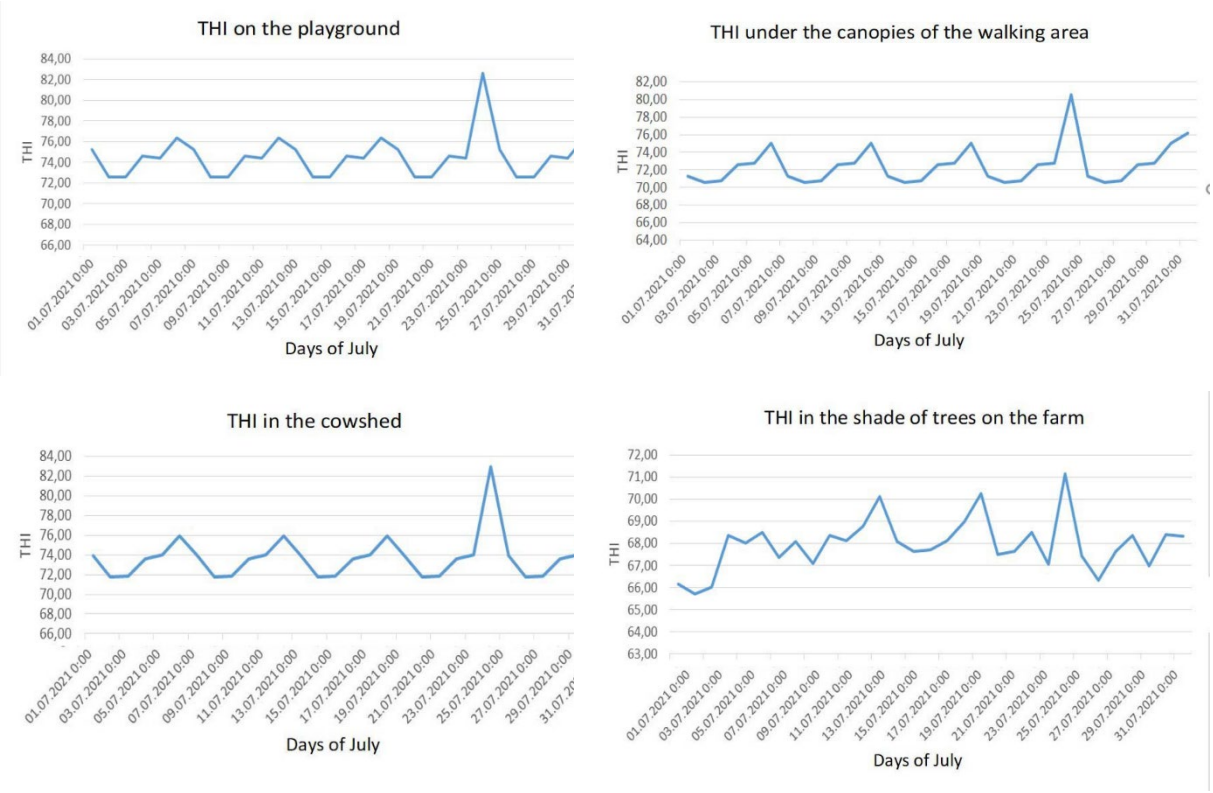

Figure 2. TNI temperature and humidity indices in different zones on the farm

Cows are able to maintain a relatively stable body temperature level at 38.5 °C (+/- 0.5 °C) and thereby cope with fluctuations in ambient temperature. The optimum temperature for the life of cows is from -4 to + 18 ° C, if the ambient temperature rises above this level, the cow must adapt. When a critical level is reached, we can talk about heat stress. But, heat stress is caused not only by ambient temperature. In addition to

temperature, you need to take into account the relative humidity of the air at the same time. To effectively counteract heat stress, it is worth focusing on certain temperature regimes and the reaction of animals to them (Figure 3).

Comparing the indicators of TNI and the indicators of productivity of highly productive cows, there was a decrease in productivity with an increase in the TNI indicator at the level of 72 or more, which indicates the presence of heat stress in cows.

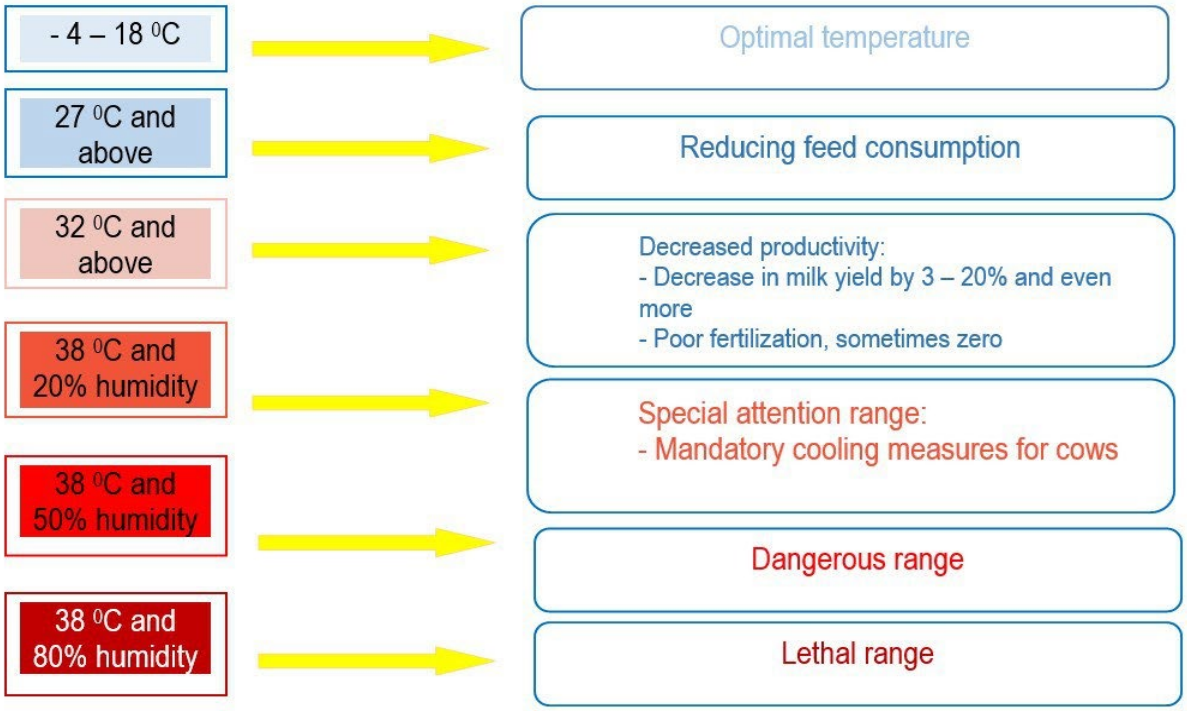

Figure 3. Influence of temperature and humidity on the productive performance of cows (*based on the publications of Richard Adams and Virginia Ishler «Reducing Heat Stresson dairy cows»).*

The average values of the average daily milk yield in the sample (n = 10) of ten highly productive cows with an increase in the TNI of the temperature and humidity index decrease their indicators, the lactation curve has a gradually linear character (Figure 4).

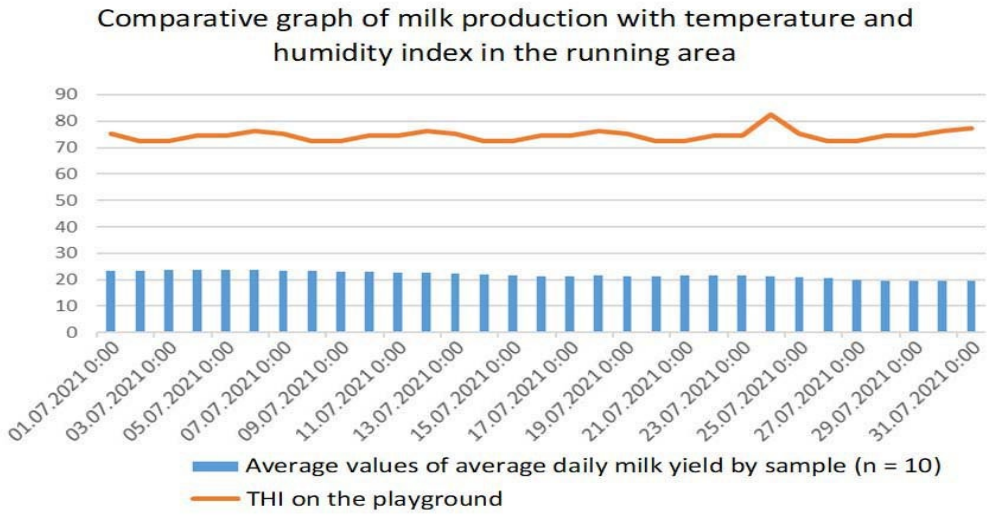

Figure 4. Comparative graph of milk production with the temperature and humidity index at the walking area for the month of July

Based on the data obtained, we can conclude that heat stress significantly affects the milk productivity of cows, and if measures are not taken to prevent heat stress or mitigate it, then during the hot period of the summer season, the enterprise will suffer large economic losses. To prevent these negative consequences, it is necessary to take possible measures, and this applies to landscaping the territory of livestock enterprises. This is evidenced by the indicators of TNI in the shade of trees on the farm, where they were the most favorable for the conditions of keeping animals and did not exceed the critical indicators for the occurrence of heat stress in cows even in hot weather, which once again confirms the effectiveness of the use of green spaces as an effective way to protect animals from heat stress.

In the conditions of summer overheating, the problem of improving the environment of livestock farms by regulating the temperature regime has become of great importance due to the trend of climate warming.

Green spaces can significantly affect the microclimate, lowering the temperature and increasing the speed of air movement, which in hot summers has a beneficial effect on the body of animals and creates a comfortable heat sensation. Plants primarily affect the radiation regime, reducing the intensity of direct solar radiation.

The cooling capacity of green spaces is largely explained by the consumption of

a large amount of heat for evaporation and an increase in relative humidity. The leaves have a temperature well below the ambient temperature. The calculation showed that on 1 hectare with 198 beech trees, having 23.6 million. leaves, the total leaf surface was 5.6 hectares, and 790 spruce trees also had 4128 million hectares per 1 ha. needles with an area of 12.8 hectares.

Different types of plants have the ability to reflect, absorb and transmit sunlight in different ways, depending on the physiological structure of the leaves, structure, crown size, etc. The best effect on lowering the temperature is given by trees with large leaves (chestnut, oak, large-leaved linden, holly maple, silver poplar, plane tree, etc.).

Albedo, depending on the density, arrangement of leaves and crown shape, varies in trees and shrubs in the range of 8-46%. Trees with the highest albedo provide the best protection against thermal energy, and their application is of great practical importance. It should be borne in mind that the albedo of the entire crown of the tree is 12-15% less than the albedo of individual leaves. The smaller the leaf, the less heat energy the crown of the plant reflects. The albedo of conifers is much lower than deciduous. It must be borne in mind that the leaves are exposed to solar heating mainly in the upper part of the crown.

The crown transparency coefficient is defined as the ratio of the intensity of direct solar radiation under the crown to the flux of direct radiation falling on an open place (Table 2).

Aspen passes through the leaves almost 10 times more heat energy than the Manchurian walnut or hawthorn, and at the same time the albedo of aspen is about 2 times higher than the albedo of these plants. The albedo of the lawn is 20.5%.

On the territory of green spaces, the radiation regime, and as a result, the air temperature change depending on the assortment of trees, their age, the density of crown closures, and tiering (Figure 5).

For example, according to long-term average data, in the pine forest of the forest-steppe zone, the soil temperature is 6-6.2%, and the trunks are 4.1-4.3% higher than in deciduous ones. Radiation among plantations varies significantly depending on altitude. If we take the radiation on the surface of the crown as 100%, then directly

Table 2. Characteristics of the passage of light energy through the crowns of trees, %

Tree	Crown transparency coefficient	Absorption	Albedo
Warty birch	6,5	5,55	38
Siberian hawthorn	1	62	37
Summer oak	8,5	41,2	50,5
Horse chestnut	10	38,5	51,5
Maple golyleafia	6	44	50
Crimean linden	5	72	23
Black alder	5	58	37
Aspen	9,5	29	61,5
Manchurian walnut	1	71	28
Hungarian lilac	5	63	32
Balsamic poplar	5,5	55	39,5
Common bird cherry	2	78,5	19,5
Apple	10	36,5	53,5

under the crown it is only 30%, at a height of 1 m above the soil - 25%, and on the grass cover - only 10%, creating the most favorable conditions.

With a horizontal closure of the crowns equal to 1, less than 10% of the solar radiation entering the open area penetrates under their canopy. A closed canopy traps solar energy and prevents radiation from the soil surface. Under dense crowns, direct solar radiation in the hottest period of the day is practically not felt by a person, because it is below the household threshold (0.07 cal/cm2 per minute of its sensation). A decrease in closure by only 0.01 increases radiation, depending on the time of year and period of the day, by 5-10%.

In the southern regions, for landscaping areas that are used from 9 am to 3 pm, tall plants with dense crowns are recommended that can shade lawns, park roads, recreation areas, sports grounds, protect the walls of architectural and engineering objects from overheating, etc. Trees with a highly developed and high openwork crown reduce radiation and convection temperatures and, due to better ventilation, increase the impact of plants by 1.3-1.5 times. Under these conditions, the most favorable areas for animal recreation are located on the northern slopes.

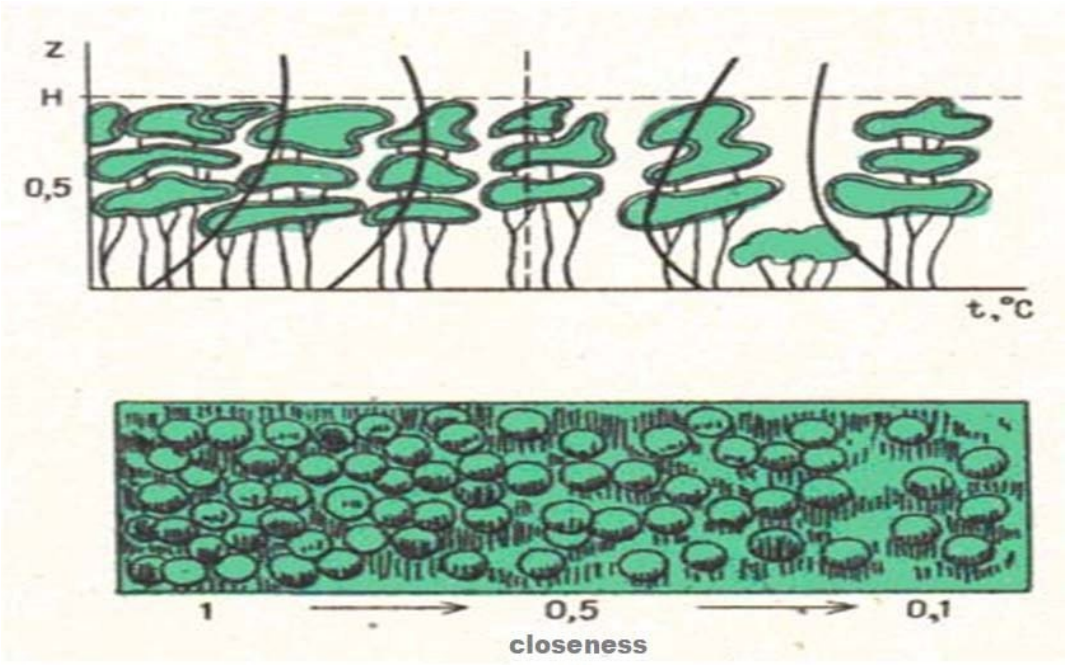

Figure 5. Vertical distribution of air temperature in plantings with different closures of the canopy.

When the asphalt pavement and retaining walls are exposed to the sun, they heat up to 60 and 55 °C, respectively, and the thermal radiation reaches 0.5 cal/cm2 per minute. If sand concrete slabs are laid instead of asphalt, and the retaining wall is covered with climbing plants, the radiation will be only 0.16 cal/cm2 per minute.

Small areas of green spaces and sparse planting can reduce the air temperature not only inside the massif, but also in the surrounding area, but slightly.

By placing plants taking into account the orientation of roads, the location of engineering structures and architectural objects, using coatings with optimal hygienic characteristics, using vertical gardening, it is possible to affect the comfort of the thermal regime (Table 3).

The formation of the thermal regime is influenced by the size of the landscaped area. The air temperature inside the livestock green area is on average 2-3°C lower than in walking yards, on on-farm areas.

Within a radius of 100 m to the green massif, the air temperature is 1 - 1.5°C lower due to the circulation of air masses near the plantations. The air heated in the open area rises upwards, giving way to colder air coming from the green massif.

Table 3. Microclimatic efficiency of green spaces and elements of external improvement in conditions of overheating.

Elements of landscaping of outdoor landscaping	Decrease in air temperature, °C	Increase in relative humidity, %	Decrease in wind speed, %	Decrease in the intensity of direct solar radiation, %	Decrease in surface temperature, °C
Array of green spaces with a density of 0.8 - 1	3,5 - 5,5	10 -20	50 - 75	95 - 100	20 - 25
Group of trees	1 - 1,5	4 - 6	20 - 40	94 - 96	12 - 20
Row planting of trees	1 - 1,5	4 - 7	30 - 50	95	12 - 19
Lawn, flower garden	0,5	1 - 4	-	-	6 - 12
Pergola entwined with plants	1 - 1,5	-	20 - 30	80	-
Sheds	0,5 - 0,8	-	20 - 40	20 - 100	-

Existing norms require in the hot summer period of the day the mandatory restriction of insolation in certain areas of the economic territory. The effect of landscaping on the thermal regime can be significantly increased by combining green areas and reservoirs. If perimeter development leads to stagnation of air heated from the walls of structures, then free planning techniques with the inclusion of large areas of greenery improve ventilation, reduce air temperature in hot weather, improving the microclimate of buildings.

Another property of plants should be taken into account - to maintain the surface temperature of tree trunks up to 10 ° C in winter, which, with dense plantings and a decrease in wind speed in arrays, softens the microclimate.

The magnitude of the impact of green spaces on the thermal regime of economic territories is determined by:

- formation of an optimal system of green spaces, including a variety of territories (in size, functional purpose, structure, species composition of plants, landscape methods of organization, etc.);
- wedge-shaped introduction of sufficiently large green areas into the depths of the building;
- density of trees and shrubs, which provides shading of at least 50% of the

territory occupied by them.

Air humidity and green spaces. Microclimatic conditions are considered favorable for humans and animals with a relative humidity of 30-70%. Vegetation, which has a high evaporation capacity, affects the humidity and temperature of the air, causing positive heat sensations of animals. An increase in relative humidity almost always (except for days with very high temperatures) is perceived by humans and animals as a certain decrease in temperature. Thus, an increase in humidity by 15% seems to reduce the air temperature by 3.5 °C.

High humidity inside green spaces in comparison with open areas is uniform, does not have sharp fluctuations, this is due to the fact that the evaporating surface of green spaces (trees, shrubs, grasses) is 20 times or more larger than the area occupied by these plants. Green spaces, as it were, regulate humidity: during the period of dryness, plants increase evaporation, at high humidity, water vapor condenses on the leaves which are cooler surfaces.

It should be noted that the relative humidity on the territory of the livestock farm, as a rule, is lower than in natural conditions, which is the result of radical changes in the properties of the surface (roof, roads contribute to the rapid removal of precipitation from the territory of the enterprise).

Techniques for placing green spaces and their combination with open spaces largely determine the relative humidity of the air. The best results in creating a comfortable environment are achieved by alternating trees and shrubs located in compact massifs with glades with dense grass cover.

Green spaces and air movement. Air movement is the most important factor determining the microclimate of areas of the economic territory, especially in the summer, when it affects the heat perception of humans and animals in conditions of overheating of the environment. The most favorable wind regime for animals is from 0.5 to 3 m/s, in which branches sway easily and leaves rustle. Green spaces contribute to the creation of constant air currents that can mix and refresh the air even in conditions of complete calm.

Using tree and shrub plants, it is possible to improve the ventilation of the entire

economic territory or its individual parts, protect outbuildings from adverse winds, regulate air movement, weaken and increase the speed of its movement, and change the direction of flow.

In hot climates, the size of the leaves in the crown of trees and shrubs becomes important. The smaller the leaf, the more thermal energy the crown can absorb. Biological processes that occur in plants cause significant cooling of the air, which sinks down and displaces the lower layer of warmer air.

Vertical air exchange is especially important on calm summer days. Its occurrence is facilitated by ruptures between the crowns (vents). Thickened plantings impede air circulation. Due to the difference (up to 10 - 12°C) in air temperature between the landscaped and open or built-up area, there is a horizontal movement of air masses from green areas to the surroundings. At the same time, warm air rises up, giving way to colder air. When green areas are located on higher areas in relation to buildings, the intensity of wind formation increases significantly, and the air speed reaches 1 m/s. Such air currents (breezes) occur in the presence of a large array of green spaces, as a rule, on the outskirts of the farm territory and with a temperature difference of at least 5 °C, a pressure difference of at least 0.7 mm Hg. Century. With an increase in wind speed, the air temperature remains constant, but its circulation increases. On a hot summer day, air movement is especially noticeable after sunset, when heated surfaces emit thermal energy. On such a day, the air movement on the territory of the farm is directed from the array of green spaces to the buildings, and at night, as a rule, the air moves in the opposite direction to the green, which is more thermally stable.

On cool days, air currents are not formed. By using different designs of green spaces and using various methods of their placement, it is possible to influence air flows, change the direction of movement and air speed.

A group of structures that are not blown is a strip of tightly closed crowns of trees and shrubs of different heights, and such groups are often created three-tiered: in the lower tier, shrubs - hazel, viburnum; on average - maple, linden; In the highest tier there is an oak. The air flow flows around the group from above and from the sides, without penetrating inside. At the same time, the wind speed begins to drop even on

the approaches to the strip. Due to friction against the tops of trees, the speed over the massif is damped up to 50%, but approaching the zone of "negative" pressure existing behind the band, the air flow again receives additional acceleration. At the point of speed restoration, air movement is turbulent and depends on the density of plants, the resulting turbulences negatively affect the soil, plants worsen the microclimate.

The windbreak effect of a narrow dense green strip of 8 rows of trees 15-17 m high and shrubs is noted at a distance equal to 30-40 tree heights, after which the wind speed reaches its original value.

The openwork design group is less dense. Part of the wind flow, penetrating into the green massif, loses a significant supply of energy for the formation of heat from the friction of air particles on trunks and branches, the other flows around the obstacle from above. With strips of openwork structure, the wind speed will decrease, but to a lesser extent than not blowed, but their effect affects a greater distance, equal to 40-50 heights of trees growing in the strip.

Standing alone in an open place, an openwork group reduces the wind speed around it. Openwork structures are most effective for protecting pedestrian trails, playgrounds from the wind, they are located across the wind flow.

The group of blowing structures are mainly single-tiered, which freely pass the wind flow, which, having entered the group, is divided into two: the lower, passing through the gaps under the crowns, and the upper one, passing above the crowns. In such strips, the wind speed will decrease to a lesser extent than in windproof or openwork groups, but it is with a blown structure that the influence of the strip extends much further (up to H = 50-60) than in the second groups, without causing turbulent disturbances.

The effectiveness of groups of green spaces is determined by their species composition, cross-section of the massif, crown development, height, degree of openwork of plants, density of undergrowth. Horizontal ventilation of the territory of green spaces is provided by a system of compact groups, arrays of plants and open spaces. When placing trees and shrubs, one should take into account the need to use plants to reduce the speed of air movement during strong winds and exclude the

possibility of unwanted ones.

In areas intended for visits, plantings of an openwork structure should be used as much as possible, which gives the necessary shade and optimal ventilation. Good microclimatic conditions are created by trees with highly raised (more than 3 m) closed spreading crowns. They provide sufficient shading and normal ventilation. Depending on the size of the space under the crowns, vertical and horizontal ventilation improves.

Windbreaks can be in the form of ordinary (regular) or group (irregular) plantings. It is possible to significantly dampen the air flow from below or even mutually if the green stripes, windproof and ventilated, are less than 10 m from each other at a distance of one height of trees. Depending on the speed and strength of the wind, the width of the strips from the side of the prevailing winds can be increased to 20-30 m or more. Although the effect of protective strips depends on the height of the trees, dense lawns also reduce wind speed by 10%. Complete attenuation of the wind in the massif is possible in the presence of closed crowns in the upper tier and dense undergrowth, and the plants must be evergreen, because the effectiveness of windbreak of hardwoods drops sharply after the leaves fall.

The landscaping system of a livestock enterprise plays the most important role in creating favorable microclimatic environmental conditions for animals. This is especially evident in extreme conditions. Thus, in hot climates, it provides protection from dry and dusty winds and at the same time contributes to the ventilation of the territory of the enterprise, purifying its atmosphere from harmful pollutants. The ventilation of the central parts of the farm, located in the depths of the building, is helped by wedge-shaped arrays of green spaces, stretched in the direction of favorable winds. Such large arrays can even increase the speed of air flow, for which they create special gaps in the form of clearings or a system of open spaces, including lawns and flower beds.

Conclusions.

The conducted studies make it possible to assert that reducing the air temperature on the territory of livestock enterprises by increasing the area of green spaces is an effective way to prevent heat stress in animals. Therefore, in order to reduce the effect of temperature on productive animals, it is necessary to provide landscaping in areas free from development, which do not have a hard surface, as well as along the entire perimeter of the farm. Green spaces, Performing the functions of biological filters, they should occupy at least 50% of the farm territory, we propose to gradually increase the number of green spaces to the proposed norm. This method improves the microclimate on the territory of livestock enterprises, reduces the negative impact of livestock production on the environment, increases the resistance of the animal body to diseases associated with group keeping, increases the productivity of animals by avoiding the consequences of heat stress and improving metabolic processes in the body of animals. Reduces the energy consumption of livestock production.