

## **SURVEY OF WAYS OF REDUCTION OF HEAT LOAD IN BUILDINGS FOR ANIMAL HUSBANDRY IN SUMMER SEASON**

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**Abstract.** Reduction of heat in buildings for housing of animals is required in order to decrease the influence of climatic change and extremes of temperature. Extreme temperatures of air as well as standard summer conditions are for some farm animals on the limit of UCT and it is necessary to use modification technique, to decrease the risk of arising of stress in animals. The reduction should be done by means of construction, isolation parameters and equipment for active reduction of heat stress. It is necessary to prevent decrease of production and problems caused by heat in animals by means of adiabatic cooling and increased air movement in the area for animals or by suitable combination of both mentioned techniques. It is necessary to test the possibilities of reduction and to define economically effective methods within the defined criteria for reduction.

**Key words:** thermal conditions, thermal stress of animals

### **INTRODUCTION**

Reduction of heat stress in buildings for housing of animals is an important and very topical measure in the technology of environment in conditions of continental climate. Its economic reasonableness is mainly in elimination of heat stress because of its negative impact on animals. Each animal species responds to heat stress in a different way and therefore are necessary different construction and technical measures to eliminate it. Up till now are in our country not precisely determined economical criteria that would unambiguously define economical efficiency of techniques used to reduce increased and high temperatures. However, mainly during extreme summer conditions it is inevitable to apply and verify selected techniques for reduction of extreme temperature conditions.

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## RESEARCH PROBLEMS

### Demands and criteria according to animal species

At present is topical the requirement to define temperature criteria for individual species and categories of animals also for the summer period. The main purpose is to provide breeding without problems, without impact and influence on production, state of health and reproduction. Therefore these criteria are being defined practically continuously. In our search for starting point we can methodically start from similar climatic regions, expected course and influence of extreme continental conditions, the occurrence of which will repeat and be more frequent than winter extremes according to bio-meteorologists. This statement is in practical terms the basis in orientation to provide requisite arrangements and effective reduction of heat stress by available measures.

Demanded are particular measures that can be used in breeding practice to reduce heat stress in breeding dairy cows with the aim to decrease its influence on milk efficiency.

In pig breeding are important deteriorated reproduction parameters and growth intensity with temperature extremes.

In poultry breeding – broilers – it is important to prevent mortality in the course of breeding because there change the needs for temperature according to the age of chickens, within the span 10–15 K. In question is also the quality of laying in breeding egg layers.

In literature are the problems defined in the sphere of growth intensity and reproduction parameters for intensive breeding rabbits.

According to the report of the International Commission of Agricultural Engineering are for our conditions proposed non-traditional criteria that must be kept if the mentioned negative processes and consequences for individual animal species are to be turned off, especially in summer heat extremes [Chiappini and Christiaens 1992].

### Settlement of criteria

The meteorological – microclimatic element air temperature is the starting point to determine the criteria for heat stress reduction in buildings for housing of animals. It presents itself very negatively during some years, and has its evidence capacity in early onset of increased and high air temperatures in spring months already. In this way increases the number of days in the year that have negative impact on physiological functions of organisms of bred animals, and the course in time during extreme tropical days and nights influences significantly the amount of milk production, gains in fattening, egg-yield and production quality.

High temperature presents itself negatively also in reproduction traits – e.g. fertility of cocks, mortality in poultry breeding – broilers if the critical moments, upper temperature conditions that can be still tolerated by individual species and categories of farm animals are not respected.

In our climatic zone – continental climate – becomes this extreme course of weather more and more evident and often and therefore it is inevitable to deal with measures that will enable to modify effectively the above-mentioned negative traits.

The research can therefore contribute to the whole process of reduction by assessment of further new criteria that will make the possible measures more precise and will make it possible in agricultural – breeding practice to focus on measures providing effective reduction, modification in our conditions of continental climate, mainly at frequent extreme temperature conditions.

It is necessary to point out the fact that the conditions, critical temperature and at present also other microclimatic parameters, relative air humidity and speed of air movement mainly in the zone of stay of animals are not defined exactly in form of norm or other form, that must be kept if we want to avoid negative consequences of non-standard microclimatic conditions.

Existing norms or rules and regulations define as a rule optimum required parameters of air temperature, partly of humidity regime, properly in thermoneutral zone. They do not determine broader zone from the viewpoint of ability of organisms to adapt themselves within a broader zone. Namely in such way that keeping it causes no negative impact, mainly decrease of production. If the broader zone is exceeded occur often non standard conditions and the animals are not able to compensate without decreased feed intake, followed by decreased production as well as death losses as we noticed in poultry breeding, broiler fattening or deterioration of reproduction parameters.

A number of problems with construction design, changes in use of buildings, heat insulation properties, systems of ventilation participate in the mentioned state. The main deficiency at high intensity of animal breeding is also the fact that the buildings are often not able to fulfil the function; they are constructionally and technically not dimensioned, and they are not equipped with devices to decrease effectively the risk factors of non-standard microclimate in extreme situations that become evident repeatedly in our climatic zone recently. The mentioned situations are defined by following and repeated findings, e.g. Šottnik et al. [1983]. As a rule there were found very low cooling effects – cooling values on the level approx.

$50 \text{ W}\cdot\text{m}^{-2}$  and less. Even in specific conditions were not measurable the cooling values, i.e. in given and so detected microclimatic conditions (if they were  $0 \text{ W}\cdot\text{m}^{-2}$ ) are they completely unfit for decrease of heat stress of organism. In such conditions become fully evident the above-mentioned deficiencies in breeding [Šottnik et al. 1998].

The point in question is the economy of the whole sector or section of breeding farm animals, returnability of the high inputs, sustainable economic potential of the given sector, ability to produce continually without negative impacts that make it difficult to get additional investments in modification equipment and in running costs to cover their higher consumption of energy when in operation.

### **Modification of microclimatic factors**

Factors that are to be modified are determined on the basis of their hitherto analysis, periodicity of their occurrence that repeats functionally and in time, and they are as follows:

- air temperature,
- air humidity in space with animals,
- cooling effects of moving air,
- course and level of air flow in space with animals.

Also protection against direct and intensive sun radiation or resulting temperature of sun radiation in place where the cumulative effects of heat radiation become evident can be considered.

In conditions of practice it is convenient to combine the mentioned factors and to achieve more favourable resulting effect compared with the state – parameters that appear as undesirable, negatively influencing reactions of organism in animals (mainly decreased feed intake, level of their production and state of health, partially also mortality).

In cattle – cow – breeding are the requirements on modification derived from THI index – Thermo Humidity Index – and its new elaborated criteria for the given sphere DI – Discomfort Index [Gates et al. 1995].

In this sphere we have only a little information for the conditions in pig breeding. From information about pig breeding in Australia, in typically summer conditions, follows that fertility, feed intake and efficiency of feed utilisation can be reduced at temperature over 30°C. Spraying equipment can reduce the effect of high air temperatures. Pigs are sprayed until they are completely wet; pigs are cooled by evaporation, water absorbs their body temperature.

In Iowa they determined air-humidity stress index for growing to end categories of pigs; in individual sections are defined zones of vigilance – danger up to urgency.

**Basic objective** – the output should be binding bases to individual parameters – elements of microclimate, in which dimensions they should be kept to prevent decrease of efficiency, negative influences in consequence of high air temperature and insufficient air flow connected with it – its insufficient cooling effect, cumulation or increase of heat in the building for housing that decrease the ability of organism to release heat produced within the superheated building.

### Reduction technique

Active reduction technique is applied in dependence on animal species, and on construction of buildings and their layout:

- in the space for animals,
- building for housing, waiting room before milking, feeding site,
- runs for cattle if there are any,
- corridor or functional interspace, for instance chambers with suction and possibility of air treatment by humidification,
- systems with underground exchanger – air supply can be also put among the mentioned construction and technical solutions,
- or special space provided for treatment of supplied air – e.g. in herds of fattening pigs, in pre-fattening of pigs.

As a rule it is the production building in poultry breeding – in fattening of broilers.

## Reduction techniques abroad

A number of new active technical means are used to treat the breeding environment abroad at present. They are tested experimentally in cattle – dairy cows – breeding, pig and poultry breeding.

From the more recent solutions is documented for instance the direct adiabatic /evaporation/ cooling of air in stable. Its humidifying is the basis for temperature decrease in poultry, cattle and pig breeding.

Further is used the technique of additional – supporting fans to cool the organisms of animals by more intensive air movement.

For the heat reduction is used sliding fans, tunnel ventilation, humidifying fans, humidifiers of PAD type (cooling walls), and simple as well as special pressure – aerosol-humidifying equipments.

### Tunnel ventilation

Tunnel ventilation (Fig. 1) reduces the heat stress effectively. Originally it was used in South America on poultry farms to prevent heat stress during extremely hot summer days. Later started this system to be used also in cattle and pig breeding.

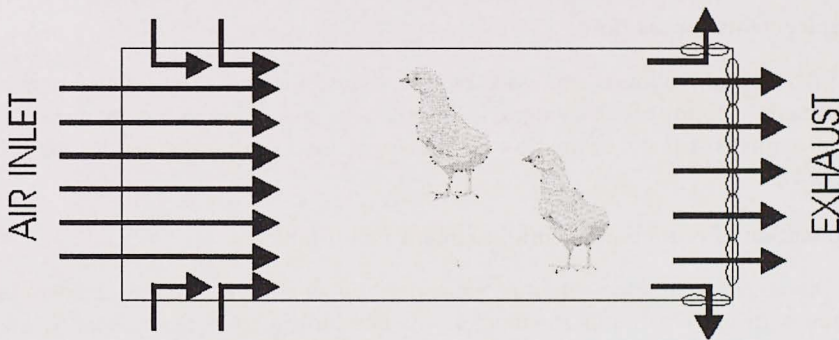


Fig. 1. Tunnel ventilation  
Rys. 1. Wentylacja tunelowa

### Principle of tunnel ventilation

Layout of ventilation units – their location in buildings is very simple compared with traditional systems of ventilation, transverse unit ventilation. Heavy-duty ventilation units are placed on the front of the building and on its one flank, the air is drawn in from the opposite flank. The air flows with increased speed through the section of the building – through its profile in the zone in which the animals dwell.

### Increased exhaust of heat produced by animals

In summer period, in conditions with increased and high temperatures, it is inevitable to exhaust heat produced by organisms of animals into the surroundings of stable mainly to provide heat stability of organism.

For exhaust of heat from organism of animals are defined four basic mechanisms for its release, namely: conduction, convection, radiation and evaporation.

Heat release by conduction and radiation is conditional on differences in temperatures between surfaces of animals and pertaining surface temperatures; heat release is limited by these mechanisms, mainly if the temperature differences are small. Such condition occurs often in good insulated delivery rooms in summer period, in tying stalls.

For comparison's sake the "convection" heat exhaust is influenced not only by differences in temperatures between ambient temperatures and animals but also by air flow. Higher air flow helps generally to release heat from bodies of animals more quickly; it creates better cooling effects.

Tunnel ventilation is constructed and designed deliberately to increase air flow; it will enable the animals to release heat by convection – air flow.

Increase of heat release by animals by means of tunnel ventilation during hot summer period has practical consequences, namely:

- decrease, prevention of mortality from heat stress,
- improvement of feed intake, weight gains, feed conversion and milk efficiency,
- increase in stocking rate.

### **Requirements for air flow**

Effect of air motion is expressed by effective temperature; it is the temperature felt by animals. Cooling effect changes, is differentiated according to species and category – age of animals. Effects of air flow at effective temperature are given for adult broiler chickens.

### **Application of reduction techniques in our conditions**

The above-mentioned solutions are especially suitable at extreme temperature fluctuations in our conditions in summer. Air humidification is recommended for some categories also in winter season. At low specific humidity of outside air  $x_e$  [ $\text{mg}\cdot\text{m}^{-3}$ ] it is necessary to humidify the dry air after warming to required temperature. As introduction of these solutions will necessitate additional investment it is necessary to test the mentioned tendencies and new technical solutions experimentally in our conditions also. After the character of their solution aim at further possible application to improve the surroundings for animal breeding in summer and winter seasons. The result should be effective creation of internal microclimate mainly if occur extreme temperature fluctuations in summer season and in prospect also climatic change with prognosticated increase of air temperatures.

If the mentioned techniques are not used at extreme outer microclimatic conditions and period of their duration then occurs decrease in performance, deterioration of feed conversion, even mass death losses in fattening of broiler chickens, mainly before the end of fattening, i.e. at stage when they have the least ability to tolerate high temperatures, the heat stress. In our conditions becomes decisive the possibility of effective investment to provide return of used modern techniques to modify microclimate, reduce

heat stress in buildings mainly with increasing temperatures outside and inside of them; mainly with extreme temperatures with the course of daily temperatures over 30°C, often to 35°C and higher (up to 38–39°C), with minimum temperatures over 25°C.

Attainable reduction of temperature in buildings will be conditioned by possibilities of active or passive influencing moisture air thermodynamically – parameters of outside – supplied and mainly interior air. Namely by technique that will enable it on the basis of thermo-physical processes of adiabatic cooling (evaporation) that will cool the air in the area of mentioned process, i.e. in building or its neighbourhood – feeding place, waiting-room for milking parlour – within the planned function of the technical equipment, direct adiabatic cooling, application of special ventilation technique and the like.

## CONCLUSIONS

At present it is necessary to pay more attention to questions of excessive thermal load in buildings for animal breeding, frequent air temperature fluctuation into its extreme values. This problem comes into prominence because of early onset of days with above-average temperatures, in spring months already, causing serious problems in a complex of questions, not only in herds of animals in our climatic conditions. From the above mentioned follows it is necessary to up-date detailed theoretical and practical scientific and technical discussion about the future progress, to define newly the problems of individual species, categories of farm animals.

Limiting criteria and parameters of possible heat stress and methods to achieve them should be newly defined from experimental knowledge. To eliminate negatively operating temperature conditions there are necessary economically available construction and technical-technological and breeding measures.

At present are on our technological market a number of technically different equipment the operation and function of which is to be tested in detail and as soon as possible to achieve new defined criteria.

Basic aim should be conclusions and recommendations of operation and exploitation parameters inclusive of control of the whole process of increased heat stress reduction in conditions of breeding farm animals.

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## PRZEGLĄD SPOSOBÓW OGRANICZENIA EMISJI CIEPŁA W BUDYNKACH DLA ZWIERZĄT W OKRESIE LETNIM

**Streszczenie.** W okresie letnim potrzebne jest zmniejszenie emisji ciepła w budynkach dla zwierząt w celu ograniczenia wpływu zmian klimatycznych i wartości ekstremalnych temperatury. Zarówno ekstremalne wartości temperatury powietrza, jak i standardowe warunki letnie są dla niektórych zwierząt gospodarskich na granicy dopuszczalnej temperatury i dlatego konieczne jest użycie technik modyfikacyjnych w celu zmniejszenia ryzyka powstawania stresu u zwierząt. Ograniczenie emisji ciepła powinno polegać na zastosowaniu odpowiednich rozwiązań konstrukcyjnych i izolacji termicznych budynków oraz ich wyposażeniu w celu ograniczenia stresu zwierząt. Należy zapobiegać problemom spowodowanym przez nadmiar ciepła za pomocą procesu adiabatycznego i wzrostu ruchu powietrza w strefie bytowej zwierząt lub przez zastosowanie odpowiedniej kombinacji obydwu wymienionych technik.

**Słowa kluczowe:** warunki termiczne, stres termiczny zwierząt

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