A REVIEW ON ENVIRONMENTAL MANAGEMENT OF RABBIT PRODUCTION

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***Abstract:** Recent paper was focused on the environmental requirements of indoor domestic rabbit production and welfare indices of the rabbit were collected from the results of several researchers. The following environmental features were studied: microclimate (room temperature, relative humidity, and air movement), air pollutants, illumination, noise and overcrowding, and other housing conditions of rabbits. The minimum requirements for housing conditions are becoming increasingly stringent in the European Union, but unfortunately the consumers' demands and the proposals on regulation are often do not take into consideration the real needs, physiology and ethology of rabbits and/or the European rabbit farmers' interest in competitiveness on the world market.*

***Key words**: rabbit production, microclimate, air quality, illumination, welfare*

INTRODUCTION

The behaviour of domestic rabbits is quite similar to that in the wild [21]. However, farmed rabbits are kept in an artificial environment. In order to raise the well-being of captive animals, like rabbits, their physical and psychological environment should be refined by providing stimuli which meet the animals' species-specific needs [1; 19].

Effects of various parameters of breeding cages, such as floor type vs. footpad injuries [20; 37; 38; 39; 41], slat distance on the behaviour of does [35], size of the cage [44], as well as social behaviours of bucks being in visual contact [32], the role of visual contact on the reproductive performance of does [15], the mode of housing of breeding does [31; 40; 42] have already been studied by several authors.

Rabbits kept on floor spent less time with resting or grooming and remarkable more time with eating than the animals kept in wiremesh cages [36]. This is in accordance with the fact that wire cage housing for rabbits is considered most economical and is more widespread [31; 43; 44].

The main welfare indicators to assess rabbit housing are mortality, morbidity, physiological parameters in the species-specific standard, species-specific behaviour and performance on a high level. In May 2007 guidelines for the housing of rabbits under the aspects of animal protection and welfare were published in Germany [18].

Recent paper was focused on the environmental requirements of indoor domestic rabbit production and welfare indices of the rabbit were collected from the results of several researchers. The following environmental features were studied: microclimate (room temperature, relative humidity, and air movement), air pollutants, illumination, noise, overcrowding and other housing conditions of rabbits.

MATERIALS AND METHODS

In this paper the authors present a literature review of environmental conditions in rabbit production. The authors studied different scientific research results in the topic, and collected data for requirements for rabbit houses. The work was induced by a debate on the standard of minimum environmental requirement of the rabbit production in the European welfare regulation, which is in progress. The selection of sources was made by the subjective opinion of the authors due to volume constraints, but it was based on the biology of the domestic rabbit.

RESEARCH RESULTS

Mikroclimate

One of the major constraints of rabbit production is environmental conditions, especially high temperature that adversely affects reproduction and growth performance. For this reason, several studies have addressed the effects of heat stress in order to find solutions to alleviate its impact on rabbit performance [16; 31]. Marai *et al.* (2002) published an important review paper in the subject dealing with the effect of heat stress on rabbits' production, reproduction and physiological performance.

Rabbits are sensitive to heat stress, they have only few active sweat glands and the elimination of surplus body heat is difficult for them, when the ambient temperature is higher than the optimum [24]. Ogunjimi *et al.* (2007) measured thermal comfort in a naturally ventilated rabbit building using temperature humidity index (THI) for both animal and breeder, while relative strain index (RSI) fore the breeder. They found that ventilation opening and building orientation have significant effects for the levels of both indices on one hand and for both rabbits and the breeder on the other.

Exposure of bucks and does to serious heat stress in summer has negative affects on the growth, breeding performance and decreases the resistance to different diseases [24; 26]. In does the reproductive traits (e.g. conception rate and litter size) and milk production reduced and age at sexual maturity and mortality increased by the affect of heat stress. In males the serum testosterone level, the spermatogenesis, libido, ejaculate volume, motility and concentration of sperm were decreases and temporary sterility appeared, the number of abnormal and dead sperm were increased by the exposure to severe excess heat. The profound changes in biological functions of the rabbits are caused by the depressed feed intake and disturbances in the metabolism of water, energy, etc. When the exposure has high temperature-humidity index (THI $\geq$ 30), rabbits unable to regulate their body temperature and heat stroke sets in.

Marongiu *et al.* (2006) examined the effects of high environmental temperatures on water-to-feed ratio (an important index for heat stress estimation) and daily weight gain of rabbits. They found significant differences by comparing OUT vs. IN rabbits; namely, both for water-to-feed ratio (for the benefit of OUT rabbits) and daily weight gain (for the benefit of IN rabbits).

Frangiadaki *et al.* (2003) evaluated reproductive performances of intensively reared does under farm conditions in Greece during the summer (hot) and winter (moderate) period. They found that litter size at birth and at weaning were significantly smaller, while pre-weaning mortality rate was significantly higher in the hot period. Hot climate is, among other things, the main cause for abnormal maternal and sexual behaviour. A doe that is capable to produce 10 litters a year may give only 4 to 5 litters in hot climate [25]. Ribikauskas *et al.* (2010) found a statistically significant positive correlation between environmental temperature and activity of rabbits.

Liao *et al.* (2014) examined temperature, humidity and wind speed in a breeding barn in China. They found that humidity in some parts of the barn was extremely high that contributed substantially to heat stress.

The optimal thermo-neutral zone for rabbits is between 15-25°C [8]. Minimum temperature of not smaller than 15°C is advisable for does at time of kindling and lactation, as well as for growing rabbits. Rabbits are much more tolerant to low temperatures than high temperatures. Above 35°C they can no longer regulate their body temperature, so heat prostration sets in. Relative air humidity (RH) should not be higher by about 5% than that of the outside air [19]. Water vapour emission of rabbits substantially increases above 20°C air temperature [10].

Ventilation in rabbit houses

Based on the above-mentioned issues, ventilation and cooling system in rabbit farms is an extremely important task: in spite of this, a relatively rarely examined area. Ventilation provides fresh air; reduces humidity; dilutes or kills airborne, disease-causing organisms and harmful gases from the rabbit house [43]; and helps control temperature. If the building is located in an area with constant breezes, natural ventilation may fully operate, substituting the use of cooling systems. However, in several cases this is not the case [3].

Borso *et al.* (2006) found that evaporative pads made of cellulose, installed in housings with transversal ventilation, showed an average efficiency of 90.5% with different values of external temperature and relative humidity, while plastic pads showed average efficiency of 61.4%, that increased only with high temperatures and low relative humidity.

Cooling systems were able to reduce, but not always to avoid, the danger of heat stress. The cooling effect sorted by these systems on incoming air proved to be very good. At the same time, high relative humidity reported in the housings substantially reduced the positive effect of the system, causing occasionally moderate stress conditions even with efficient cooling pads [4].

When global solar flux is high during early in the afternoon, a metal roof partly reflects, partly absorbs irradiance. Painting the roof with a reflective white or aluminium, paint will increase the proportion reflected. This is desirable because the absorbed part of the radiation raises the temperature of the roof. This hot roof then produces long-wave heat radiation that is directed downward into the rabbitry and onto the rabbits. To protect rabbits from this long-wave radiant heat coming from the roof, it may be necessary to build a ceiling in the rabbitry or to install insulation between the rafters to prevent radiation of heat down from the roofing [29].

Studying the role of cross ventilation and longitudinal ventilation in different rabbit buildings, Borso *et al.* (2016) found that the correct positioning of gas sensors for regulating ventilation systems must be central in case of cross ventilation, but close to the suction fans in case of longitudinal ventilation.

Since rabbit house is completely enclosed, the environmental factors such as temperature, humidity, harmful gases, as well as illumination, etc. may severely affect the health and the reproductive function of rabbit [3]. With regard to this, economic benefits of rabbit farming may be substantially improved by manually regulating the microclimate of the rabbit house. Guo *et al.* (2016) designed a rabbit house temperature regulation system to adjust the temperature of the rabbit house through the water curtain filtration and negative-pressure ventilation method. Also, their procedure utilizes the internet, namely temperature and humidity data, as well as gas concentrations on every rabbit house are uploaded to a background server via wifi connection to the network, in order to enable the poultry feeders to make a real-time observation on the environmental information of the rabbit house, including remote control of the water curtain and the running of the blower on their smart phones. Furthermore, Guo *et al.* (2016) built a model for the rabbit house temperature with the application of a fuzzy-PID control algorithm and the variable frequency drive technology in order to design a controller for any further decline in the system power consumption, based on the optimal control. Verification of their result proved that the system could be controlled reliably with technical feasibility.

Liberati and Zappavigna (2005) prepared a computer model for optimizing the internal climate in a rabbitry. They considered building parameters, kind of breeding and geographical coordinates, as well as speed and direction of airflow and internal air temperature and humidity. By simulating the internal climate, they could optimize the thermal performance of the building during the whole year. This allowed to reach the best compromise in building design between climatic conditions of the cold and hot seasons.

Peng *et al.* (2016) designed a modified heat recovery ventilation (HRV) system for a rabbit house in order to improve the indoor environment and reduce heat loss in a cold region. They found that the HRV system had a moderate performance in sensible heat recovery effectiveness, and no significant difference was observed when the outdoor temperature varied from -15°C to 5°C. However, the HRV system was proven to better resist freezing than the traditional system in cold working conditions. It could operate even in conditions when the maximum difference between inside and outside temperature reached 26.55°C and when the lowest outdoor temperature was -15.06°C.

Flores-Velázquez *et al.* (2017) used computational modeling to study the natural ventilation method in a typical rabbitry in Central Mexico. Decreased temperature and concentration gradient of ammonia were found after a design modification of inlet vent.

Noise and overcrowding

Noise in rabbitries causes adverse effects including nervous and behavioural abnormalities and can cause a startled response and traumatic injuries to limbs and back. Particularly, most concern about noise effects has traditionally focused on impairment of reproductive and maternal behaviours [25]. Overcrowding may make rabbits aggressive and they may bite one another during the first few days of nest sharing, while successive litters live together.

Illumination

Ribikauskas *et al.* (2010) established a statistically significant positive correlation between illumination and activity of rabbits [36]. Furthermore, providing 16 hours of light year around, will help overcome winter reduction in the reproductive rate [29]. Liao *et al.* (2014) monitored breeding environmental indicators for rex rabbits, including illumination in a breeding barn. They found that distribution of illumination was uneven. Improving light regime contributed to the well-being of rabbits. A lighting schedule was elaborated (16 hours light and 8 hours dark [28]), the light performance was 50 W/m^2 [9].

Air pollutants

Air pollution from animal production has become an important issue. Unfortunately there is a shortage of scientific results regarding the emissions of pollutant from rabbit farms. The rabbit production is a potential source of atmospheric pollution such as ammonia (NH_3) which can cause respiratory diseases as well as eutrophication and acidification in the environment; methane (CH_4) and nitrous oxide (N_2O) are greenhouse gases; furthermore the high concentrations of airborne particulate matters (PM) can have adverse effects on health, welfare and environment as well [3; 7]. The emission levels of ammonia and nitrous oxide of rabbit farming are usually higher than in other animal species [7]. The dust level, the relative air humidity (RH) and concentrations of harmful gases in the rabbit barn should be kept as low level as possible, which is not dangerous for rabbits [18].

Airborne PM concentrations are significantly influenced by the human activity performed in the stable rather than by the rabbits' activity. PM emission levels (g/h) are slightly higher in the buildings of growing rabbits compared to does' ones. Emission rates expressedin the unit of g/h/animal are lower than in poultry, pigs or cattle production [7].

Bonci *et al.* (2011) studied environmental and hygienic parameters, including temperature, relative humidity, speed of airflow, total dust, concentrations of noxious gases (i.e. NH_3, CO_2, CH_4 and H_2S), airborne bacteria and fungi, in an intensive fattening rabbit farm in Italy. The highest levels of RH were measured during summer, due to the evaporative cooling system activation. The highest NH_3 and CO_2 concentrations occurred parallel to minimum airflow rates (i.e. cold season, night-time, early hours). CH_4 concentrations were highest in summer, whereas peak values of H_2S concentrations happened when manure scrapers were in operation. Total dust levels were higher during autumn and winter, when minimum ventilation levels occurred.

Calvet *et al.* (2011) determined concentration and emission of harmful gases (NH_3, N_2O, CO_2) in rabbit farms in the Spanish Mediterranean area. They found that indoor temperature and relative humidity followed a sinusoidal daily course throughout the year. Furthermore, maximum gas concentrations did not exceed the threshold values established for human health and animal welfare. Ribikauskas *et al.* (2010) showed a significant positive correlation between NH_3- and CO_2 concentrations on one hand and activity of rabbits on the other. Levels of CO_2 is a powerful indicator for regulating ventilation rates in animal buildings. Estellés *et al.* (2010) associated daily concentration levels of carbon dioxide with daily patterns of animal activity. They observed an exponential relationship between animal weight and carbon dioxide emission. Sinusoidal daily patterns of carbon dioxide emission and relative animal activity were also determined. In addition, they found a positive relationship between carbon dioxide emission and relative animal activity.

Estellés *et al.* (2009) designed a flux chamber in order to measure emissions from small farm animals and their manure, as well as proposed a methodology to calculate ventilation fluxes appropriate for each experiment. Liao *et al.* (2014) examined breeding environmental indicators of rex rabbits, comprising CO_2 and NH_3 concentrations of a breeding barn in China. They concluded that an effective ventilation may significantly improve the well-being of rabbits [10].

Indoor environmental conditions vs rabbit related diseases

While dermatophytoses of several animal species have been extensively investigated, information on their occurrence and epidemiology in rabbits is limited. Cafarchia *et al.* (2010) found that the occurrence of lesions, the age of rabbits and farm management (e.g. temperature, humidity and methods and frequency of disinfection practices) are significant risk factors for the occurrence of dermatophytes. They also established that animals in fattening and finishing stages were the most frequently infected. Dermatophyte prevalence was significantly ($P<0.05$) higher in areas with higher temperature (>20°C) and relative humidity ranging from 62–65% [5].

Dependence of micro-organisms on climate elements is confirmed by Miao *et al.* (2010), who found that composition and variability of airborne fungi in an enclosed rabbit house may be in close relationship with temperature and relative humidity. As regards hygienic parameters, *Pasteurella multocida* seems to be influenced by seasonal conditions, probably due to wide and rapid fluctuations in temperature, relative humidity and airflow, as well as to high relative humidity levels, showing an increasing trend from spring to autumn. The dermatophyte *Microsporum canis* indicates the highest levels in correspondence with minimum airflow rates (i.e. winter) [2; 3].

Liao *et al.* (2014) found that peak concentrations of CO_2 and NH_3 resulted in colds, pneumonia and diarrhea among rabbits, in particular the survival rate of pups reduced to a mere 62.5%. Effective measures, such as increased ventilation significantly improved the indoor air quality and hence life quality of rabbits.

CONCLUSIONS

The collected scientific results confirm some environmental indices for rabbitries:

a) the required temperature range of the stable is 15-25°C;
b) the required relative air humidity in the stable is between 50-70%;
c) the rate of ventilation is minimum 3 m^3 of air / h / kg body weight);
d) maximum air speed in the building on the level of animals: 0.3 m/s.

Well-being of domestic rabbits is an important component for their undisturbed, economic and cost-efficient production. Therefore, the proper keeping of rabbit is one of the vital aspects of rabbit breeding. The aim of the paper is to modernize of rabbit barns partly from animal welfare point of view and partly from economic reasons. Nevertheless, the reasons behind our purpose are associated: namely, they confirm each other. In other words, one cannot be implemented positively without affecting the other.

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