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Criteria of response and adaptation to high temperature for reproductive and growth traits in rabbits

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SUMMARY - Rabbits are very susceptible to heat stress, as they have few functional sweat glands and have difficulty in eliminating body heat when the environmental temperature is high. Exposing the female rabbits to high ambient temperatures (above 30°C) impairs the reproductive performance and embryonic development and increases the mortality rate among the offspring. In males, heat stress also affects deleteriously the testicular function and semen characteristics. Moreover, body weight and growth decrease due to hyperthermia. Different methods for amelioration of heat stress such as sheltering, drinking cool water, air conditioning, sprinkling tap water and shearing, have been shown.

Key words: Heat stress, reproduction, growth, mortality, thermotolerance, amelioration.

RESUME - “Critères relatifs à la tolérance et l’adaptation aux hautes températures chez le lapin, du point de vue des caractères reproductifs et de croissance”. Les lapins sont très sensibles à la chaleur, car ils n’ont que peu de glandes sudoripares fonctionnelles, et éliminent donc difficilement la chaleur corporelle lorsque la température du milieu est haute. Le fait d’exposer des femelles à de hautes températures ambiantes (plus de 30°C) se répercute sur les résultats reproductifs et le développement embryonnaire, et fait augmenter le taux de mortalité chez la descendance. Chez les mâles, la chaleur affecte également de façon négative la fonctionnalité testiculaire et les caractéristiques du sperme. De plus, le poids corporel et la croissance diminuent à cause de l’hyperthermie. Plusieurs méthodes ont été étudiées afin de diminuer le stress provoqué par la chaleur, telles que construire des abris, faire boire de l’eau fraîche, climatiser, vaporiser de l’eau du robinet, ou tondre les animaux.

Mots-clés: Chaleur, reproduction, croissance, mortalité, thermotolérance, amélioration des conditions.

Introduction

Human population is increasing rapidly, especially in all developing countries in Africa, Asia and Latin America. It is estimated that by the year 2000, there will be in the world an additional two billion people to feed (Allen, 1983). To maximize food production in all countries, all reasonable options must be considered and evaluated. Among these is the use of livestock species that, for one reason or another, have not played a major role in animal agriculture, such as rabbits. Such animals have a number of characteristics that make them suitable as meat-producing small livestock in developing countries. The small body size, short generation interval, high reproductive potential, rapid growth rate, genetic diversity and the ability to utilize forages and by-products as major diet components, favour them for the mentioned function (Cheeke,
Physiological response of rabbits to high temperature

Among the climatic components that may impose stress on productive and reproductive performance of the animals are temperature, humidity, air movement and radiation, being perhaps the temperature the most important one. In developing countries, the most obvious limitation to rabbit production is the susceptibility to heat stress which is a systemic stress that invokes a series of changes in the biological function of homoothersans.

A temperature of 21°C is known as the “Comfort Zone” for rabbits. At either higher or lower temperatures, the animal has to expend energy to maintain its body temperature. Exposure of rabbits to a high environmental temperature increases the heat load on animals. During the first few hot days of exposure, rabbits are more uncomfortable. Does that are well advanced in pregnancy and newborn liters are the most susceptible to injury.

Since most of the sweat glands in rabbits are not functional and perspiration (the evacuation of water through the skin) is never great because of the fur, the only controlled means of latent heat evacuation is by altering the breathing rate. The significance of the increase in respiration is that it enables the animal to dissipate heat by vaporizing the moisture through the respiratory air, which accounts for about 30% of the total heat dissipation (Abdel Samee, 1987). These systems work between 0° and 30°C, but when ambient temperature exceeds 30°C, the animal stretches out so it can lose heat as much as possible by radiation and convection and a significant increase in both rectal temperature and ear temperature occurs (Kamar et al., 1975; Shafie et al., 1982; Abo-Elezz et al., 1984 and Wolfenson and Blum, 1988). Thus the appetite is depressed, the productive and reproductive performances are impaired and the resistance to disease is decreased. Above 35°C, rabbits can no longer regulate their internal temperature and heat prostration sets in (Lebas et al., 1986).

The mortality among the offspring was found to increase significantly at temperatures above 30°C (Rafai and Papp, 1984). Particularly, exposure of rabbits to prolonged periods for more than three hours daily for a period of 8 weeks during June and July, in Egypt, increased mortality and the losses were confined to dark coloured animals (Abo-Elezz et al., 1984). Such colour absorbs great amounts of the visible spectrum (Shafie et al., 1970 and Findlay, 1972) resulting in an excessive heat load and a possible failure in the animal’s heat balance. However, such deaths might be due to the interference with the animal’s function by the failure in acid-base balance (Shafie et al., 1970). From another point of view, the study of the mortality rate in the different seasons of the year in Egypt proved that the losses were the lowest in Giza White rabbits (Ragab and Wanis, 1960) and Baladi Red rabbits (Nossier, 1970) born during January and February (Figure 1). Emara (1982) attributed the lower percentages of litter losses during January to April with respect to the remaining months of the year, to the higher availability and better nutritive value of green fodder, in addition to milder weather, especially the atmospheric temperature which prevails in January, February, March and April. However, Gualterio et al. (1988) found that the mortality rate at birth was higher in winter and summer than in spring, due to presence of some cold and hot days. El-Maghawry et al. (1988) confirmed that the month of kindling affected significantly the preweaning mortality.

The estimated heat tolerance coefficient was considerably higher for the native Giza White (76.6%) than for Bouscat (67.5%) bucks, under the environmental conditions of Egypt (Abdelrazik et al., 1985). When testing thermotolerance in New Zealand rabbits to different ambient temperatures, Fizil et al. (1988) obtained the best experimental results when the animals were exposed for a long period (90 minutes) to an ambient temperature of 25-35°C and a relative humidity of 90%.

Reproductive traits response

IN FEMALES

Under high environmental temperature, mating and conception rates or fertility of the doe appear to be lowered (Matassino et al., 1970) due to a complex set of events, which are expressed in a significant reduction in total young born and an increase in the percentage of young born dead.

Such phenomena are due to a marked decline in each of postcoital ovulation (Farrell et al., 1968), ovulation rate (Hahn and Gabler, 1971), percentage of corpora lutea associated with the formation of detectable implantation sites or viable embryos, i.e., number of implantation sites/doe and number of viable embryos/doe (El-Fouly et al., 1977). Accordingly,
seasonal differences were observed in ovulation rate (Hahn and Gabler, 1971), implantation rate, gestation period (El-Fouly et al., 1977) and litter size (Figure 1). El-Sheikh and Casida (1955) confirmed the significant effect of heat on the ratio of fertilized to unfertilized ova in test females with some recovery by 21 to 30 days after treatment. Rathore (1970) postulated that heat stress resulted in reduction of fertilization rate, smaller blastocysts and embryos and an increased embryonic mortality rate. However, Wolfenson and Blum (1988) reported that ovarian weight, embryo implantation rate and embryo survival rate did not vary significantly in rabbits as a function of exposure to hot climate. Similarly, El-Fouly et al. (1977) did not find significant effects for hot summer season on fertilization rate and the diameter of the blastocyst including the mucus coat. From another point of view, Edwards (1978) postulated that early stages of pregnancy are more sensitive than later ones to heat stress. Embryonic losses frequently occurred when the animals were exposed to severe heat stress during the first 6 days of pregnancy. In addition, it was found that embryonic mortality increased in does inseminated with heated sperm cells (Burfening and Ulberg, 1968), or when zygotes were heated during the division of the first cells (Alliston et al., 1965). However, Abo-Elezz et al. (1984) reported that heat stress may affect late embryonic or very early postnatal death rates.

Particularly, severe sustained heat stress of 35°C reduced the conception rate from 66% in the first parity to 33% in the second parity against 100% in winter (Shafie et al., 1984).

Fig. 1: Seasonal effects on litter size (1), litter weight (2), bunny weight (3) and mortality rate (4) in rabbits, under Egyptian conditions as cited from the literature.
IN MALES

Exposing the bucks to heat stress resulted in a reduction in testicular measurements (testis weight and length). This reduction suggests a degeneration in the germinal epithelium and a partial atrophy in the seminiferous tubules (Chou et al., 1974), since the average number of testicular cells, especially the secondary spermatocytes and spermatids of types B, C and D, the ratio of spermatid cells to other cells and the diameter of the seminiferous tubules were adversely affected by heat stress (El-Sherry et al., 1983a). Similar criteria were observed in domestic animals, i.e., degeneration of the germinal epithelium and seminiferous tubules were observed in bulls (Alba and Riera, 1966), rams (Voglmayer et al., 1971), boars (Mazzaria et al., 1968) and rats (Sod-Moriab et al., 1974) when exposed to heat. However, Hafez (1965) reported that the testes of farm animals do not undergo marked seasonal changes in size.

In addition, the studies in Egypt showed that exposure of male rabbits to hot summer season resulted in a significant increase in each of reaction time, total sperm abnormalities, sperm mortality rate, methylene blue reduction time and seminal plasma total calcium and fructose concentrations. At the same time, there was a significant decrease in ejaculate volume, sperm concentration, mass motility, semen density, spermatozooal total nitrogen and phosphorus concentration (El-Sherbiny, 1987). Oloufa et al. (1951) confirmed the above results in volume and concentration of the ejaculate, sperm motility and bucks sexual desire in a high environmental temperature at 35°C. The deleterious effects of solar radiation on semen quality and fertility may be attributed to sustained damage during the late stages of spermatogenesis.

Injection of the heat stressed male rabbits with LH significantly increased the total number of spermatocytes and promoted their rapid division. The number of type A spermatids increased, while that of type B decreased. The seminiferous tubules diameter, the total number of spermatogonia and spermatid cells numbers were restored to normal and the number and ratio of type B spermatogonia were restored to above normal level by the treatment. However, type D spermatids did not return to their normal level (El-Sherry et al., 1980c). Similarly, the combined FSH-LH treatment of heat stressed testes increased seminiferous tubules diameter to nearly normal, but decreased the spermatid cell number, total spermatogonia and total spermatocytes. The FSH-LH glucocorticoids treatment restored seminiferous tubules diameter, total spermatocytes and total spermatids to normal, but did not correct retarded spermatid differentiation (El-Sherry et al., 1980d). In another trial, El-Sherry et al. (1980e) found that the treatment with glucocorticoids under thermoneutral conditions increased seminiferous tubules diameter, the number of spermatocytes and number and ratio of type A spermatids, while the total number of spermatogonia and the other types of spermatids decreased. The seminiferous tubules diameter and sertoli cell number, sertoli cell ratio and the total number of spermatocytes were restored almost to normal levels, but the number and ratio of spermatogonia decreased by the treatment. The FSH treatment prevented the decrease in seminiferous tubules diameter and increased the number and ratio of type B spermatogonia and prevented the decrease in the total number of spermatocytes caused by exposing rabbits to heat stress (El-Sherry et al., 1980b).

Growth response

It is known that growth is a complex set of metabolic events which are genetically and environmentally controlled. The role of environment in the performance and health of domestic animals is well known for every specialist. However, the literature dealing with the effect of high temperature on growth of rabbits is rather conflicting.

Some studies showed that exposure of rabbits to a high environmental temperature decreased the embryo's weight and length (Radwan, 1975; Edwards, 1978 and Wolfenson and Blum, 1988), live body mass (Rafai and Papp, 1984) and body weight (Abo-Elezz et al., 1984 and Fekry, 1989) due to hyperthermia. Abo-Elezz et al. (1984) attributed that to the decrease in feed consumption and possibly to dehydration of the animals and/or to tissue catabolism. However, Abdel-Samee (1982), Kamal (1982) and Kamal et al. (1989) reported that the changes in body due to heat stress in animals are controversial and the live body weight is not a reliable estimate for detecting changes in actual tissue mass, since it depends on the changes in both total body water and body solids and the counteraction between tissue destruction and water retention. Other studies showed that exposing rabbits to heat stress (35°C and 65% RH) caused a significant increase in body weight, total body water and water turnover rate, while total body solids and biological half-life time of tritiated water (T 1/2) significantly decreased significantly (Abdelrazik et al., 1985). Wolfenson and Blum (1988) confirmed that exposing rabbits to controlled hot climate produced a slight increase in body weight at birth and a significant decrease in daily body gain. From another point of view, Ragab and Wanis (1960), Shawer (1963), Nossier (1970), Khalil (1980) and Emara (1982) reported that rabbits body weight changed according to month of birth. It increased from September to February and decreased thereafter during April and May, while litter weight and bunny weight at weaning increased from October to March and April, in Egypt (Figure 1).
However, Fekry (1989) showed that exposure of rabbits to solar radiation had no significant effects on body composition (percentages of water, protein, fat and ash), carcass composition (carcass weight and percentages of water, protein, fat and ash) and haemoglobin content.

Generally, the decrease in productivity under high environmental temperature is a result of disturbing the normal physiological balance of the animal’s body, particularly energy, hormonal, thermal and water balances (Kamal, 1975; Johnson, 1980; Abdel-Samee et al., 1989; Daader et al., 1989 and Habeeb et al., 1989). Such disturbance is expressed as negative nitrogen balance (Kamal et al., 1962; Kamal and Johnson, 1970 and 1971 and Ames et al., 1980) and negative mineral balance (Kamal and Abdelaal, 1972; Kamal and Johnson, 1977; Kamal, 1982 and Kamal et al., 1984) which are a result of the dramatic reduction in feed consumption (Rafai and Papp, 1984; Wolfenson and Blum, 1988 and Fekry, 1989). Another explanation of that phenomenon may be through the activity of the metabolic hormones and enzymes, since their concentrations decrease significantly as a function of heat stress in an attempt by the animals to diminish heat production to counteract the increased heat load (Johnson, 1980 and Abdel-Samee, 1987). Postulately, animals routinely kept under high temperature develop metabolic mechanisms to adapt to heat stress, since it is observed that in the tropics, New Zealand White rabbits are successfully raised under conditions in which the temperature is consistently 32.2 - 35.0°C, while rabbits of the same breed adapted to cool conditions of the Pacific Northwest of the United States may die of heat stress when the temperature on rare occasions exceeds 32.2°C.

Amelioration of heat stress

Temperature, humidity and air current all have a direct bearing and each rabbitry is an individual problem.

Different physical and physiological methods have been used to alleviate the heat load in heat stressed animals. The physical methods used are such as sheltering, air conditioning, zone air cooling, drinking cool water, using wet or iced sacks in the cages, spray or sprinkling the roofs and floor with tap water and shearing. However, in all cases rabbits must be kept dry, since wet coats are predisposing causes for pneumonia and respiratory troubles.

Rabbits must be protected from high temperature, rain and sun by providing adequate sheltering. Good circulation of air throughout the rabbitry is a must, but strong drafts and winds should be avoided. Rabbits that show symptoms of suffering should be removed to a quiet, well ventilated place.

In areas of high temperature such as the tropics, it is essential that the rabbits have a supply of cool water available at all times, since they consume large quantities of water and less feed than in temperate climates. Provision of adequate cool water is critical under these conditions (Cheeke, 1986).

Considerable relief can be given by placement of wet jute sacks in the cage to lie on. In the case of the doe that has advanced to the stage where hemorrhage is occurring, a quick action is necessary. Placing cracked ice between the folds of a wet jute sack and placing it in the cage to lie on, is quite effective and may save many does which are about to kindle. Immersing the entire rabbit in cold water for three seconds is another emergency measure to save heat stressed rabbits (Cheeke et al., 1982).

Sprinkling the roof and floor of the rabbitry will give considerable relief. If a roof sprinkler is thermostatically controlled, it will change the environment conditions quickly and will be especially useful if the caretaker is not available for regulating the sprinkler (Cheeke et al., 1982).

Shearing the fur coat induced a significant decrease in body skin and ear lobe temperatures. Respiration and pulse rates also decreased (Kamar et al., 1975). Removing of the fur in the mice caused a drop in body temperature and an increase in the rate of oxygen consumption by 35%.

The physiological methods used for alleviation of the heat load in the heat stressed animals are such as treatments with hormones (as injections of the males with LH, FSH... etc, which are mentioned before), antihormones, diopheretics and diuretics.

References


Poultry Production, Alexandria University, Alexandria, Egypt. 2, 637-641.


EL-SHERRY, M.I., EL-NAGGAR, M.A. and NASSAR, S.M. (1980b). Experimental study of summer stress in rabbits. 3. The quantitative and qualitative effect of FSH and FSH in combination with thyroxine on the spermatogenic cell cycle in stressed rabbits. Assiut Veterinary Medical Journal. 7 (13/14), 33-47.


