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IMPACT OF HEAT STRESS ON PREGNANT RABBITS AND ON THE DEVELOPMENT AND VIABILITY OF THEIR FOETUSES

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The remarkable reproductive potential of the rabbits is still not fully utilized in broiler rabbit production. The main reason seems to be the intra-uterine death of the foetuses under the influence of various environmental stressors /inadequate feed supply, toxicoses, heat stress, etc./ which act on the pregnant does.

Embryonic mortality is occasionally as high as 30-35 per cent in heterogeneous rabbit flocks. The mature ova produced by does /and sows/ always outnumber the actual litter sizes. The implantation rate of the fertilized ova is genetically determined. Generally about three per cent of the ova deteriorate after ovulation. Round 45 per cent of the intra-uterine deaths are consequent upon implantation failure /5/. The embryonic losses may be increased further by various adverse environmental factors, which act on the pregnant does. Depending on the type and intensity of environmental stress, the developing embryo and/or foetus suffers mild to severe damages. The damage is mainly quantitative, resulting in embryonic death, during the early stage of gestation /10/, whereas in a later stage the ab ovo poor heat tolerance of the rabbits becomes aggravated. The adverse influence of high ambient temperature on embryonic development takes effect through elevation of the maternal body temperature /6/ also in the early stage of gestation. A heat stress causing rise of body temperature by 1.2 to 1.8°C during the first six days of gestation accounts for serious prenatal losses /20/. Pre-implantation death of all embryos by maternal heat stress was also reported in sows /24/. However, Hellmann /1979/ pointed out that the effects of hyperthermia associated with a viral infection /Myxovirus A_1/ should be differentiated from those due to heat stress, because the latter gave rise to abnormal embryonic development, whereas the former did not interfere with the normal course of gestation /7/.

Since in field conditions rabbit pregnancy is established only on day 10-14 of gestation /8/, the early disturbances thereof remain as a rule unobserved, and several valuable breeding females are not infrequently culled for alleged infertility. It is, therefore, advised that the possibility of disturbed embryonic development be taken into consideration whenever a sudden drop of the pregnancy rate occurs in a rabbit production unit.

The adverse environmental influences give rise to predominantly qualitative changes in the final stage of gestation, in which the rate of the maternal energy and protein metabolism increases considerably, /2, 19/, and the foetal body mass increases five to six times. The developmental anomalies occurring in the prepartal stage, and failure of parturition despite established pregnancy, can be estimated also in field conditions by recording the number of stillborn or unviable young. Thus appropriate measures can be taken immediately.

With these facts in mind, we investigated the nature of the impact of the heat stress expectable under field conditions in Hungary on the health of the does and on the viability of their foetuses. Since we conducted the field studies in the final stage of gestation, our experimental observations can be applied directly in the production units of the broiler rabbit industry.

Experimental

Materials and Methods

Four groups of five does were accommodated on the 20th day of pregnancy in climatic chambers at 35, 30, 20 and 5°C ambient temperature, respectively. They were caged singly in cages equipped with nest box. The relative humidity of ambient air was maintained at 40, 50, 70 and 80 per cent in the above sequence.

Since the pregnant does kept at 35°C died already in the initial days of the experiment, we further on studied the impact of high /30°C/ and low /5°C/ ambient temperatures /groups I and III/ and used the rabbits of group II /20°C/ as control.

The purpose of the study having been the assessment of those climatic stress factors, which acted in the late stage of pregnancy, the temperature of the climatic chambers was adjusted to 20°C after parturition also for the two experimental groups.

The does received a granulated rabbit feed and drinking water /from nipple drinkers/ ad lib. throughout the period of the sutdy, and their feed consumption was assessed daily.

The body mass of the does was determined once every day in the morning hours, and immediately before and after parturition as well. The individual body weight of the newborn rabbits, the litter weight, and the number of unviable youngs was also determined.

The milk production of the does was estimated from body weight determinations before and after lactation. The individual body weight of the baby rabbits and the litter weight were determined at regular intervals and the litter size was determined daily. All spontaneously died rabbits were autopsied.

The body weight changes were analyzed on the basis of the post-lactation weight of does and the pre-lactation weight of the young. The health state of all rabbits was observed continuously.

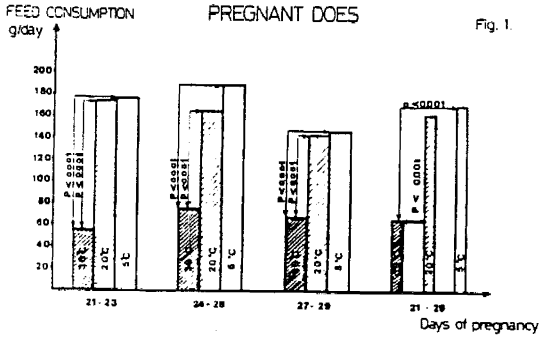
Results

All does exposed to 35°C ambient temperature in the advanced state of pregnancy died for lack of a preceding climatic adaptation in heat stroke, within 72 h, i.e. on day 23 of gestation. The mean body mass of the foetuses recovered from the dead does

was 10.2 g, the mean foetal count was 5.8 and 4.4, respectively, in the left and right uterine horn, and the mean litter size was 10.2.

The feed consumption of the does kept at different ambient temperatures is shown in Fig. 1. As can be seen, the heat-exposed does consumed significantly (p<0.001) less feed (65.9 g) in the advanced stage of pregnancy than those kept in cold (161.5 g) or optimal climatic environment (170.4 g). Fig. 1 also shows that the feed consumption of the cold-exposed does was particularly high from day 24 to day 26 of pregnancy, but tended to decrease later on, exactly as in the other two groups.

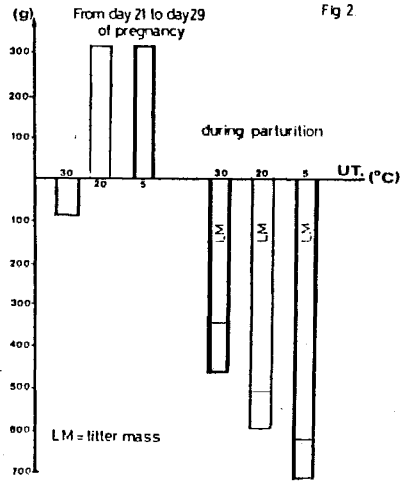
INFLUENCE OF HIGH (30 °C) AND LOW (5 °C) AMBIENT TEMPERATURES ON THE FEED CONSUMPTION OF PREGNANT DOES Fig. 1



As to drinking water consumption, the minimum was recorded in the cold-exposed group (260 g), and also the heat-exposed does consumed less water (420 g) than the control does (470 g). However, relative to unit feed consumption, the water consumption was highest (1:6.4) in the heat-exposed group, and persisted at a much lower level in the control (1:2.9) and cold-exposed (1:1.53) groups.

The body weight changes of the does are shown in Fig. 2. While the heat-exposed does lost on average 87 g weight from day 20 to day 29 of pregnancy, the does of the other two groups gained considerable weight (298 g, resp. 305 g) in the same period.

INFLUENCE OF HIGH (30 °C) AND LOW (5 °C) AMBIENT TEMPERATURES ON THE BODY MASS OF PREGNANT DOES Fig 2



The parturition-related decrease in maternal body weight was always directly related with the corresponding litter weight. The does kept in warm, cold and thermoneutral climatic environment lost 362, 702 and 590 g of body mass, respectively, by parturition. The mean litter mass was lowest (347g) in the heat-exposed group, and highest (611 g) in the cold-exposed group (Table 1).

The correlation between ambient temperature and newborn litter weight can be characterized with the function $Y = 634 - 9x$, where Y is the litter weight (g), x is the ambient temperature (^{o}C) and the resulting correlation coefficient is $r = -0.76$. It follows that, above 5°C, each 1°C temperature rise accounts for

a reduction of the partal litter weight by 9 g. No unequivocal correlation was demonstrable between the ambient temperature and the individual birth weight /r = 0.47/. The analysis of the individual birth weight demonstrated a significant decrease in the heat-exposed group /44.5/ relative both the cold-exposed and control group /Table 1/.

INFLUENCE OF HIGH (30 °C) AND LOW (5 °C) AMBIENT TEMPERATURES ON THE MAIN PARAMETERS OF THE OFFSPRING

Table 1.

	AMBIENT TEMPERATURE (°C) 30	20	5
LITTER SIZE	7.8	8.8	10.4
BIRTH MASS (g)	44.5 ± 1.4 xxx	57.3 ± 1.5 NS xxx	58.7 ± 1.8
PERCENTAGES OF UNVIABLE NEWBORN	17.9	4.5	9.6
PERCENTAGES OF LOSSES UNTIL 7 DAYS OF AGE	9.0	Ø	17.3
UNTIL 19 DAYS OF AGE	100	4.8	19.2

xxx p < 0.001

Newborn rabbits of low viability and less than 40 g body weight were regarded as unviable /23/. The high ambient temperature accounted for a statistically significant increase in the relative proportion of unviable baby rabbits, which was 17,9 per cent in the heat-exposed group and 9.6 per cent in the cold-exposed group, against 4.5 per cent in the control group /p<0.001, resp. p<0,05/.

As to early rearing losses, no baby rabbit died in the control group until the 7th postnatal day, and relatively few /4.8 per cent/ died until the 19th day /Table 1/. In the heat-exposed group 90 and 100 per cent, in the cold-exposed group 17.3 and 19.2 per cent of the young died until day 7 and day 19 post partum, respectively. The cause of death was generally smothering or starvation.

On account of the enormous losses, the experimental study was conclused in group I on day 7 of lactation, whereas in groups II and III it was continued until the 19th day.

The data of the postparturient feed consumption and of the milk production of the does are shown in Table 2.

FEED CONSUMPTION OF THE DOES AFTER PARTURITION AT OPTIMAL AMBIENT TEMPERATURE

Table 2.

	AMBIENT TEMPERATURE (°C) /30/	20	/20/	20	/5/	20
FEED CONSUMPTION (g/day)			xxx			
1st WEEK OF LACTATION	137.9 ± 16.8 xx		241 ± 17.9	NS	246 ± 14.4	
UNTIL DAY 19 OF LACTATION			2688 ± 18.5	NS	282 ± 11.6	
MILK PRODUCTION (g/day)	xxx					
1st WEEK OF LACTATION	37.1 ± 7.8 xxx		135.1 ± 9.1	NS	130.7 ± 9.8	
UNTIL DAY 19 OF LACTATION			167.7 ± 7.6	NS	166.7 ± 8.7	
FEED CONVERSION RATE IN TERMS OF MILK PRODUCTION (kg/kg)	3.72		1.78	1.6	1.88	1.7

xxx p < 0.001
xx p < 0.01

The does of groups II and III consumed significantly more feed than those of group I.

The milk production of the does showed a similar tendency. Relative to a mean daily milk production of 135.1 and 130.7 g in group II. and III, respectively, the does of group I produced significantly /p<0.001/ less milk /37.1 g/ daily during the first week of lactation. The mean daily milk production did not appreciably differ between groups II and III until day 19 either, although the mean daily feed consumption of the experimental /cold-exposed/ does was by 14.2 g higher.

The mean birth weight of the litters /Table 2/ was also similar in groups II and III /2052, resp. 2028 g/ on day 19 post partum, and the mean litter sizes were 8.0 and 8.4 respectively. The mean individual body weight of the baby rabbits was by

15.1 g lower in the cold-exposed group relative to the control.

The data on the relation of unit milk production /kg/ to unit /kg/ feed consumption /Table 2/ represent with regard to the lactation-associated body mass changes of the does only estimates. The feed conversion rates derived from these were about 3.72, 1.78 and 1.88 kg/kg for the does of groups I, II and III, respectively. Thus groups II and III did not appreciably differ in respect of feed conversion either /1.6 and 1.7 kg/kg resp./

Discussion

Rabbits adapt themselves relatively easily to the seasonal temperature changes occurring under the climatic conditions of Hungary. Pregnant does are nevertheless particularly sensitive to abrupt heat stress. In the present experiment, abrupt exposure to 35°C ambient temperature acted as a direct causal factor of disease. The premortal symptoms shown by the heat-exposed does /salivation and nervous symptoms/ indicated the onset of the irreversible changes associated with thermic shock. If such symptoms occur in a doe flock, attempt should immediately be made to reduce the body temperature of the animals, if required even by spraying with water. If the elevation of the body temperature cannot be prevented, first increase, then decrease of the respiratory rate, drop of blood pH, rise of blood HCO_3 and profuse salivation give in due course rise to hyponatraemia and hypopotassaemia, which will ultimately lead to a fatal outcome by upsetting the homeostasis.

Such an extreme heat stress does not normally occur under the climatic conditions of Hungary, unless ventilation fails in the enclosed doe house during a summer heat wawe.

As to the effect of 30°C ambient temperature, this did not directly give rise to disease, yet imposed a considerable stress on both the pregnant does and their foetuses. The does reduce their feed consumption in the warm environment considerably /9, 14, 16, 18, 21, 22/, especially in the last trimester of pregnancy. The heat-exposed does consumed in the present experiment by 59.2 per cent less feed and by 10.7 per cent less drinking water than the control does, although their water consumption increased 2.2 times over the control relative to unit feed consumption. It ought to be mentioned in this context that while Stephan and others /21, 22/ reported an increased drinking water consumption along with a decreased feed consumption in broiler and angora rabbits at 30°C, Johnson and others /9/ and Prud'hon /18/ demonstrated consistently with us reduced levels of both feed and water consumption in pregnant does under heat stress. The cause of the diminution of water consumption with rising ambient temperature seems to be the fact that the digestion of the lesser amount of feed consumed in warm environment requires a lesser amount of water than the quantity required for evaporation from the skin at high temperatures.

The feed consumption of the rabbits is regulated by the requirement for digestible protein and metabolizable energy /3, 4, 12/. In our own experiments the feed consumption was nevertheless reduced during the last trimester of pregnancy, as demonstrated also by Prud'hon /17/ and Lebas and others /11/.

The fact that irrespective of former significant differences related to the climatic environments /see groups I-II and I-III/

the does of all groups reduced their feed consumption in advanced pregnancy, prompted the hypothesis that not so much the current energy needs as certain neurohormonal mechanisms take over the regulation of feed consumption in that critical stage of gestation.

The results of the present study strongly suggest that the low /5°C/ ambient temperature affected neither the health state of the pregnant does, nor the development of their foetuses, whereas the high /30°C/ ambient temperature accounted for exhaustion of the does' energy and protein reserves by the end of pregnancy /as judged from body mass decrease/ and for a relative decrease in litter size and relative proportion of viable newborn as well. Hafez /1970/ pointed out earlier that exposure of the does to heat stress resulted as a rule in increased foetal mortality, decreased brith weight and increased unviability of the newborn rabbits /6/. Our own experimental observations indicate that the adverse effects of heat stress on both doe and foetus were associated mainly with reduced feed consumption.

The adverse effects of heat stress persisted also after parturition, despite the optimal climatic conditions provided for the parturient and lactating does. The formerly heat-exposed does consumed by 42.8 per cent less feed and produced by 72.3 per cent less milk than the control does. This was in all probability consequent upon the diminution of thyroid function by the preceding heat stress. It is known that, along with the mammogenic hormones progesteron, prolactin, STH, etc./, thyroxin, too, plays a role in the structural development and milk production of the mammary gland. According to Viard and others /25/, pregnant or lactating does having a low blood prolactin level were incapable of rearing their entire litter to adulthood. Nigmatulin /15/ incriminated the milk production disturbances of does as the main cause of early rearing losses /until 2 days of age/ in rabbit production. Löhliger and others /3/ stated that the great majority of early rabbit lossess occured until 2 days of age.

In Hungary the summer heat wawes appeared during the last 50 years on 10-13 days per annum, depending on the geographic region. In the same period the daily temperature maxima reached 34.4 and 34.8°C in July and August, respectively, in the Capital and its surroundings, whereas the mean daily temperatures did not rise above 21.9 and 21.1°C. We measured in field conditions 25, 29 or 33°C ambient temperature in light-construction doe houses. It follows that at external temperatures of 28-30°C even with efficient ventilation can not reduce the ambient temperature of a tightly stocked doe house. It is therefore recommended that, in addition to furnishing a maximal air exchange rate, the floor of the doe house should be sprayed with water, because this simple measure can reduce the ambient temperature by 3-4°C if the ambient air is not saturated with water vapour /adiabatic cooling/.

Since in summer the nocturnal drops of temperature usually stimulate feed consumption, the does may to a certain extent compensate for the adverse effects of diurnal heat.

The 90 per cent baby rabbit mortality which occurred in the heat-exposed group until the 7th postpartal day was unequivocally consequent upon the unviability and poor milk supply of the offspring. It follows that high ambient temperatures damage

in the last trimester of pregnancy not only the does, but also the foetuses, and still have a disadvantageous influence on the milk production of the does and, consequently on the development of the suckling rabbits after restoration to an optimal climatic environment. Further studies into the causes of the lactation disorders are in progress.

Summary

Four groups of five does each were kept at ambient temperatures of 5, 20, 30 and 35°C, respectively, in climatic chambers, from day 20 of gestation until parturition, after which the ambient temperature was adjusted to 20°C for each group. The does received a standard rabbit feed and drinking water ad lib. throughout the period of the study.

The pregnant does kept at the highest temperature /35°C/ died within 72 h of heat exposure, and those kept at 30°C - although they did not show symptoms of disease - consumed significantly /$p<0.001$/ less feed than the control /20°C/ and cold-exposed /5°C/ does, and also lost 84 g of body mass until the termination of pregnancy.

It should be noted that, irrespective of the former levels of feed consumption, a decrease of the mean daily feed consumption occurred in all groups from the 26th day of pregnancy onward.

The litter mass of the newborn rabbits was highest /611 g/ in the group kept at 5°C until parturition. The interrelationship between the ambient temperature of the pregnant does and the litter mass was characterized with the function $Y = 634 - 9x$ /$r = -0.76$/, where Y is the newborn litter mass /g/ and x is the ambient temperature /°C/. It follows that, above 5°C, each 1°C rise of temperature accounted for reduction of the newborn litter mass by 9 g.

The does exposed to 30°C during the last trimester of pregnancy produced significantly /$p<0.001$/ less milk /44.8 g/ during the first week of lactation than the control and previously cold-exposed does /136.7 and 137 g/day/. The low birth mass consequent upon prenatal heat stress and the low milk supplay provided by the previously heat-exposed does accounted for a 90 and 100 per cent mortality of the baby rabbits until the age of 7 and 19 days, respectively. It follows that exposure to a high ambient temperature /30°C/ during the last trimester of pregnancy affects not only the health of the pregnant does and the development of their foetuses, but also accounts for a reduced milk production under the conditions of the optimal climatic environment furnished after parturition.

Zusammenfassung

Vier Gruppen von je 5 tragenden Häsinnen wurden ab 20. Trächtigkeitstag in Klimakammern bei 5, 20, 30, bzw. 35°C Temperatur gehalten. Nach dem Wurf wurde die Umwelttemperatur für sämtliche Gruppen auf 20°C eingestellt. Während der Untersuchungsperiode wurden die Tiere mit Kaninchen-Fertigfutter und Trinkwasser ad lib. versorgt.

Die bei der höchsten Umwelttemperatur /35°C/ gehaltenen Muttertiere gingen an der Wärmebelastung binnen 72 Stunden ein. Bei 30°C erkrankten die Häsinnen nicht, verminderten aber im Vergleich zu den beiden anderen Gruppen ihre Futtereufnahme

mit p 0.001 signifikant, und wiesen bis zum Wurf einen um 84 g geringeren Körpermassenzuwachs auf.

Nach dem 26. Trächtigkeitstag ging die Futteraufnahme unabhängig von den vorhergehenden Konsum in allen 3 Gruppen zurück.

Die gesamte Geburtsmasse der Jungen erreichte in der bei 5°C gehaltenen Gruppe ihren Höchstwert /611 g/. Der Zusammenhang zwischen der Umwelttemperatur der hochtragenden Häsinnen und der gesamten Geburtsmasse des Wurfes konnte mit der Funktion Y = 634 - 9 x /r = -0,76/ charakterisiert werden, wo Y die Geburtsmasse /g/ und x die Umwelttemperatur /°C/ bezeichnet. Daraus geht hervor, dass über 5°C jede Temperaturerhöhung um 1°C eine Verminderung der Wurfmasse um etwa 9 g bewirken dürfte.

Die mittlere tägliche Milchproduktion der im letzten Trächtigkeitsdekad bei 30°C gehaltenen Häsinnen war während der ersten Laktationswoche im Vergleich zu den beiden anderen Gruppen /136,7, bzw. 137 g/ auch bei der optimalen Umwelttemperatur /20°C/ mit $p<0.001$ signifikant geringer /44.8 g/.

Geringe Geburtsmasse und unzureichende Milchversorgung führten zum Abgang von 90 % der Jungen bis zum 7. Lebenstag und von allen bis zum 19. Lebenstag in der im letzten Trächtigkeitsdekad bei 30°C gehaltenen Gruppe. Daraus folgt, dass die Wärmebelastung der hochtragenden Häsinnen nicht nur die Gesundheit der Muttertiere und die Entwicklung ihrer Leibesfrüchte schädigt, sondern auch die bereits unter optimalen mikroklimatischen Bedingungen vor sich gehende Milchproduktion erheblich beeinträchtigt.

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