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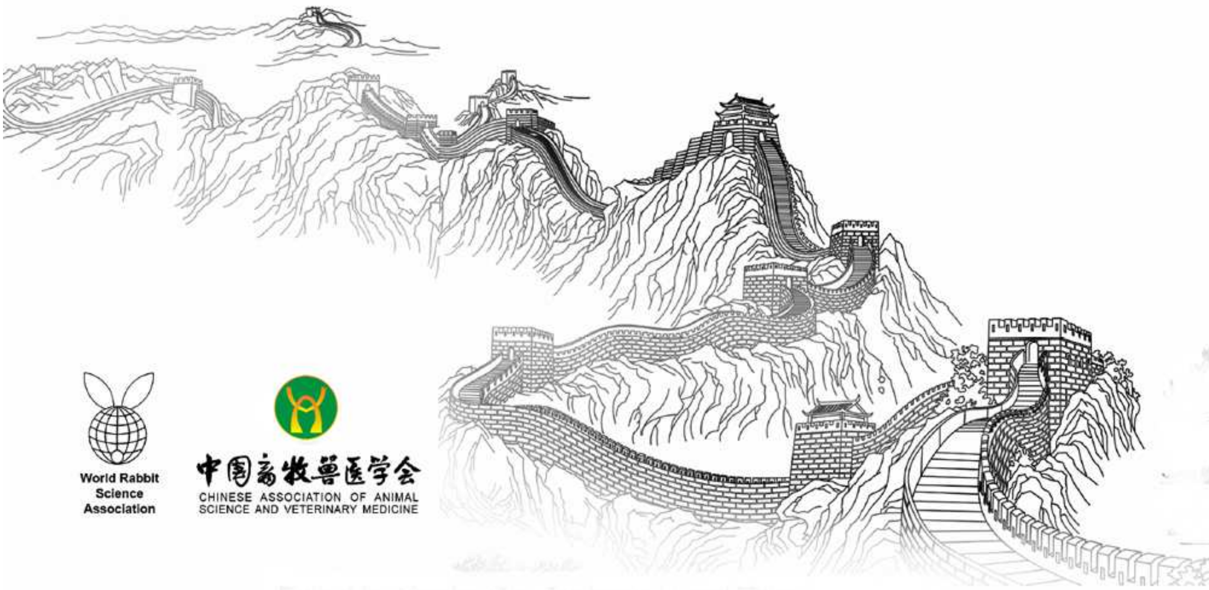

EFFICIENCY OF THE RABBIT UNDERGROUND CELL KEEPING SYSTEM IN REDUCING HEAT SUMMER STRESS

González-Redondo P.[1]*, Finzi A.[2]

[1]Department of Agroforesty Sciences, University of Seville, Carretera de Utrera km 1, 41013 Seville, Spain
[2]Centro Sperimentale Allevamenti Cunicoli Alternativi, Consorzio "Coniglio Verde Leprino di Viterbo", 01030 Vasanello (Viterbo), Italy
*Corresponding author: pedro@us.es

ABSTRACT

To assess the efficiency of the alternative rabbit keeping system based on underground cells to protect rabbits from heat stress, a trial was performed to test the temperatures reached inside the cells in relationship with the outdoor temperatures during the warm season. Six concrete and six plastic underground cells, each keeping a single doe, were tested in a farm located near Viterbo (Italy). Maximum outside temperature and maximum temperature inside the cell were measured between mid-June and early September 2013. The maximum temperature inside the underground cell ranged from 21.9 ºC when the maximum external temperature was 24-25 ºC, and reached only 26.9 ºC when the maximum external temperature increased up to 34-35 ºC, thus remaining within the rabbit thermotolerance zone. This reduction in the maximum internal temperature with respect to the maximum external temperature was significant ($P<0.001$) and ranged between –3.1 ºC when the maximum external temperature was 24-25 ºC to –7.6 ºC when it reached 34-35 ºC. In comparison with plastic cells, concrete cells showed a higher reduction of the maximum internal temperature ($P<0.05$) with respect to maximum external temperature. In conclusion, the underground cell is a simple and economic raising system that keeps low its internal temperature when the outside temperature is high, offering self-conditioned environmental conditions that are cooler in summer and fit to protect the rabbits from heat stress while avoiding air-conditioning costs.

Key words: Rabbit, Alternative keeping systems, Underground cell system, Heat stress.

INTRODUCTION

An alternative keeping system based on an underground cell connected to an external cage was developed in the early 80's by the Rabbit Unconventional Keeping Centre in Viterbo (Italy) to protect rabbits from heat stress in North Africa (Finzi, 1987). It was later found that it was a very appropriate system to maintain good health conditions when it was applied in Italy. Alternative units adopting the underground cell system are managed by small stakeholders who raise the breed Leprino of Viterbo (Finzi, 1990; Finzi *et al.*, 1995) to integrate the rural income, mainly in the Viterbo province (Finzi, 2004; Finzi *et al*., 2004; Finzi *et al*., 2014). Most of these farms use concrete cells, but some farms use also plastic cells because concrete cells, though less expensive, are much heavier and difficult to set correctly.

Despite the fact that the underground cell system has been empirically shown effective in cushioning heat stress of rabbits (Finzi *et al.,* 1992a; Finzi *et al.*, 1992b), to date no specific temperature measurements have been checked. Therefore, the aim of the present study was to characterise the temperatures reached inside two models of the underground cell system in relationship with the outdoor temperatures during the warm season. This will provide relevant knowledge about the efficacy of this alternative rabbit keeping system in naturally reducing the cell micro-environmental temperature to protect animals from heat stress.

MATERIALS AND METHODS

The study was carried out in an alternative farm located in the Viterbo province (Italy) where the climate is subtropical mediterranean, as to say mitigated by the presence of the Mediterranean Sea. The sheltering system (Figures 1 and 2) was formed by the cells that were catch basins (drain boxes) covered with earth till the upper rim (Figure 3) and they were connected by a tube to external cages (De Lazzer and Finzi, 1992; Finzi, 2004). Cells were closed by a movable insulated lid (Figure 2) that made them explorable to control the nest (Figure 3) and to clean after each reproductive cycle. The does, individually housed, could move from the cell to the cage, freely choosing the more convenient environment (the fresh cell in the warm days).

Two experimental groups were formed by six concrete and six plastic (polyethylene) underground cells. Both models of cells measured 50×50×50 cm (Figure 3). The walls of the concrete cells were 3 cm thick and those of the plastic cells were 4 mm thick.

Figure 1: Cells (left) and cages (right) are connected by a tube.

Figure 2: The experimental set: two cells are under each lid.

Figure 3: In the underground cell a proper nest can be set.

A thermometer was placed inside each underground cell. The environmental temperature of both treatments was measured in the shadow under the roof that sheltered the keeping system. Maxima temperatures were measured three times a week on Tuesday, Thursday and Saturday between mid-June and early September 2013 both outdoors and inside the cells, and a total of 720 data was recorded along the 60 days in which the measurements were performed.

For each range of external maxima temperatures, a) two independent samples *t*-tests were performed to compare the maximum temperature inside the cell between concrete and plastic cells, and b) dependent *t*-test for paired samples were performed to compare the external maximum temperature and the maximum temperature inside the cells. In addition, a Pearson's correlation coefficient between the maxima temperatures inside the cells and the maxima external temperatures was calculated. The statistical analyses were performed using SPSS v.15.0 software (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Figure 4 shows the maximum temperature reached inside the underground cells when the maximum external temperature increased from 24 to 35 ºC. The maximum temperature inside the underground cells ranged from 21.9 ºC, when the maximum external temperature was 24-25 ºC, to 26.9 ºC when it increased up to 34-35 ºC. This demonstrates the efficiency of the underground cell in keeping the inner cell temperature near to the range adequate for rabbits. In fact, thermotolerance zone of the species is comprised between 10 and 25 ºC (Ferré and Rosell, 2000), and the underground cells were able to maintain its maximum inner temperature within this range when the maximum external temperature reached up to 31 ºC. Even when the maximum outside reached up to 35 ºC, the maximum internal temperature remained below 27 ºC (Figure 1), a temperature still tolerate by rabbits. This effect is favoured by the underground position of the cells whose heat is dispersed in the soil in which they are embedded, as occurs in natural burrows.

In practice, the thermal efficiency of the underground cell is fit to eliminate the summer heat stress of rabbits and the reproductive seasonality in farms using this keeping system, the latter at least in terms of the main parameters characterising the does' reproductive performance (González-Redondo *et al*., 2008). Moreover, while the buildings used in the conventional rabbit farming, in the area considered, must necessarily be conditioned, in the alternative system air-conditioning costs are totally eliminated. Costs reduction and simplicity of facilities become very important elements in favour of the use of the underground cell system in developing countries (Finzi and Mariani, 2011).

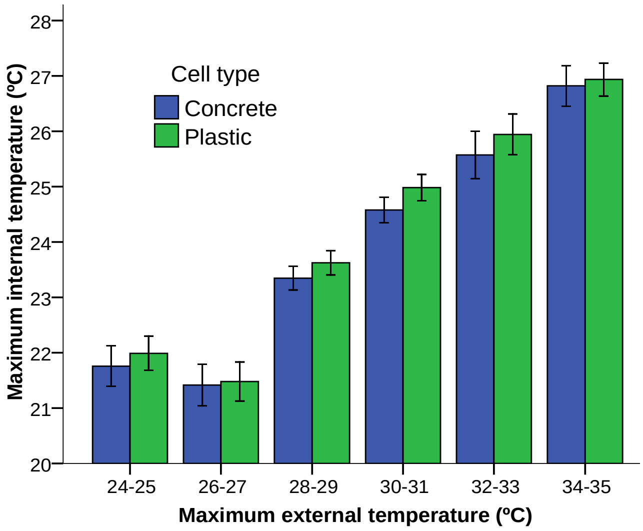

Figure 4: The trend of cells maxima temperatures for increasing external maximum temperature are clearly correlated when the latter increases over 27 ºC.

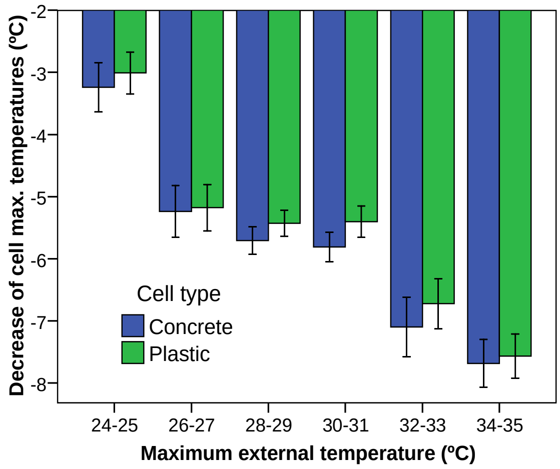

Figure 5: Decrease of cells maxima temperatures in relationship with the increasing of external maximum temperature.

Figure 5 shows the difference between the maximum external temperature and the maximum temperature reached inside the underground cell for each range of maxima external temperatures. The maximum temperature inside the underground cell was reduced (P<0.001) with respect to the maximum external temperature for all the maximum temperature ranges comprised between 24 and 35 ºC. This reduction in the maximum internal temperature with respect to the maximum external temperature ranged between –3.1 ºC when the maximum external temperature was 24-25 ºC to –7.6 ºC when it reached 34-35 ºC. This represents a negative correlation (r = – 0.676; P<0.001) between the maximum external temperature and the reduction in the maximum temperature inside the cells. Concrete cells produced a higher reduction (P<0.05) than plastic cells in the maximum temperature inside the underground cells with respect to the maximum external temperature, that amounted up to 0.5 °C. The better efficiency of the concrete cell in reducing temperature by dispersing it into the ground is due to the better thermal conductivity of concrete compared to plastic (The Engineering Toolbox, 2015).

For the usual temperatures in the Mediterranean area, even if the plastic cell is a bit less efficient, the maxima internal temperatures obtained are sufficient to eliminate the summer thermal stress which would occur if the rabbits were reared in cages inside a building without air-conditioning. Therefore, where convenient for technical reasons, the plastic cells can be used without major drawbacks. Anyhow, the problem of materials to build rabbit shelters (costs, availability and efficiency) can become important in programs for rural development. In fact, farmers can easily build *in situ* the concrete cells by themselves, manually and at low cost (Finzi, 1987).

Ambient temperature over 35 ºC is not common in the area where the trial was carried out but the trend of the experimental data suggests an increase of the system efficiency with increasing environmental temperatures. Thus, when during the hot hours of the day external temperature reaches about 40 °C the internal temperature, according to the observed trend, should not exceed 30 °C. In fact, in the North African hot season, where even 38-40 °C in the shade are reached during several hours, the underground cell system has already shown a good efficiency in reducing thermal stress and allowing reproduction even when the local practice is to suspend mating for four months because the feed intake of rabbits declines sharply and they are not able to reproduce (Finzi and Mariani, 2011).

CONCLUSIONS

The underground cell is confirmed as a rabbit keeping system, proposed for small farmers, fit to lower its internal temperature when outside temperature is high, offering a self-conditioned environment that is cooler in summer and fit to protect the rabbits from heath stress. Concrete cell was slightly more efficient than plastic cell in reducing the maximum temperature inside the cell with respect to the maximum external temperature. Although both cell types can be utilised according to the local technical and economic conditions, concrete cells tend to become preferable when environmental temperatures are high.

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GONZÁLEZ-REDONDO P.[1]*, FINZI A.[2]

[1]Dpt. Agroforestry Sciences, University of Seville, 41013 Seville, Spain
[2]Centro Sperimentale Allevamenti Cunicoli Alternativi,
Consorzio "Coniglio Verde Leprino di Viterbo", 01030 Vasanello (Viterbo), Italy

E-mail: **pedro@us.es**

Pedro González-Redondo

Underground cell system is efficient in maintaining the inner cell temperature near to the range adequate for rabbits, eliminating heat stress and air-conditioning costs

INTRODUCTION

- The alternative keeping system based on an underground cell connected to an external cage (Fig. 1-3) was developed in the early 80's by the Rabbit Unconventional Keeping Centre in Viterbo (Italy) to protect rabbits from heat stress in North Africa.
- It was later found that it was a very appropriate system to maintain good health conditions when it was applied in Italy. Alternative units adopting the underground cell system are managed by small stakeholders who raise the breed Leprino of Viterbo to integrate rural income, mainly in the Viterbo province.
- Most of the farms use concrete cells, but some farms use plastic cells because concrete cells, though less expensive, are heavier and difficult to set correctly.

OBJECTIVE

- To characterise the temperatures reached inside two models of the underground cell system (concrete and plastic cells) in relationship with the outdoor temperatures during the warm season. This will provide evidence of the efficacy of this alternative rabbit keeping system in naturally reducing the cell micro-environmental temperature to protect animals from heat stress.

MATERIAL and METHODS

Location

Alternative farm in Viterbo province (Italy), with subtropical Mediterranean climate.

Sheltering system

Cells were catch basins (50x50x50 cm) covered with earth till the upper rim (Fig. 3) and connected by a tube (Ø14cm) to external cages (Fig. 1). Cells were closed by a movable insulated lid (Fig. 2) that made them explorable to clean and to control the nest.

The does, individually housed, could move from the cell to the cage, freely choosing the more convenient environment (the fresh cell in the warm days).

Experimental groups

6 concrete (Fig. 3) and 6 plastic (polyethylene, Fig. 4) underground cells. The walls of the concrete cells were 3 cm thick and those of the plastic cells were 4 mm thick.

Measurements

Maxima temperatures were measured inside the underground cells. The maxima environmental temperatures were measured in the shadow under the roof that sheltered the keeping system.

Temperatures were measured three times a week between mid-June and early September 2013. A total of 720 data was recorded along the study period.

Figure 1: Cells (left) and cages (right) are connected by a tube.

Figure 2: The experimental set: two cells are under each lid.

Figure 3: Nest inside a concrete cell.

Experimental groups

Concrete cell **Plastic cell**

Figure 4: Nest inside a plastic cell.

RESULTS and DISCUSSION

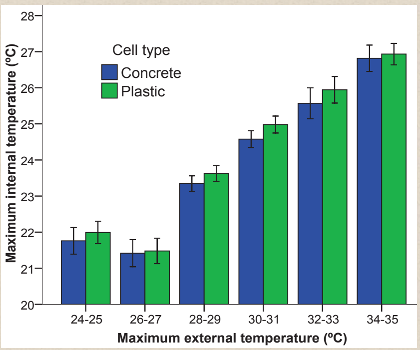

Fig. 1 - The trend of cells maxima temperatures for increasing external maximum temperature are correlated when the latter increases over 27 ºC.

The **maximum temperature inside** the underground cells ranged from **21.9** ºC, when the *maximum external temperature* was *24-25* ºC, to **26.9** ºC when it increased up to *34-35* ºC.

Even when the maximum outside reached up to 35 ºC, the **maximum internal temperature remained below 27 ºC**, a temperature still **tolerate by rabbits**.

Effect favoured by the underground position of the cells whose heat is dispersed in the soil in which they are embedded, as occurs in natural burrows

The **maximum temperature inside the cell was reduced** (P<0.001) **with respect to the maximum external temperature** for all the maximum temperatures between 24 and 35 ºC. This reduction ranged between **–3.1** ºC for the *maximum external temperature* of *24-25* ºC to **–7.6** ºC when it reached *34-35* ºC.

Concrete cells produced a **higher reduction** (P<0.05) than **plastic** cells in the maximum temperature inside the cells, that amounted up to 0.5 °C. The better efficiency of the concrete cell in reducing temperature by dispersing it into the ground is due to the better thermal conductivity of concrete compared to plastic.

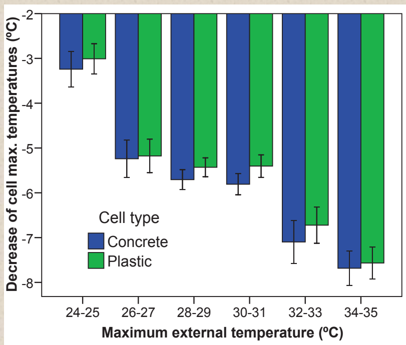

Fig. 2 - Decrease of cells maxima temperatures in relationship with the increasing of external maximum temperature.

Negative correlation (r = –0.676; P<0.001) between maximum external temperature and the reduction in the maximum temperature inside the cells.

CONCLUSIONS

- The underground cell is confirmed as a rabbit keeping system, proposed for small farmers, fit to lower its internal temperature when outside temperature is high, offering a self-conditioned environment that is cooler in summer and fit to protect the rabbits from heath stress.
- Concrete cell is slightly more efficient than plastic cell in reducing the maximum temperature inside the cell with respect to the maximum external temperature.
- Although both concrete and plastic cells can be utilised according to the local technical and economic conditions, concrete cells tend to become preferable when environmental temperatures are high.