EFFICIENCY OF THE RABBIT UNDERGROUND CELL KEEPING SYSTEM IN MAINTAINING GOOD THERMAL REGIME UNDER COLD WEATHER CONDITIONS

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ABSTRACT

An alternative open-air rabbit keeping system, called "Underground cell system", has been adopted in Italy since more than 30 years and it is slowly and spontaneously wide-spreading in rabbit keeping commercial units which produce a very appreciated and well-paid high-quality meat at low input costs. The system is based on a cell covered with earth till the rim and connected by a tube to an external cage, simulating natural conditions and offering a sheltering preferred by does even if they could accede to a free-range area. The cell offers micro-environmental conditions that are fresher in the hot season and warmer in cold season. Since the nest is set inside the cell and kits are sensible to cold, the internal cell temperature has been tested in the cold season in comparison with the external temperature. Six concrete and six plastic underground cells, each keeping a single doe, were tested in a farm located in Viterbo (Italy). Minimum outside temperature and minimum temperature inside the cell were measured between mid-December 2013 and early April 2014. The results show that the difference ($P<0.001$) between the external and the internal temperature increases with the decrease in environmental temperature and the concrete cell was slightly but significantly more efficient than the plastic cell ($P<0.05$). When outside temperature lowered until −2/−4 °C the internal temperature of the cell remained 9-10 °C higher and sufficient for the nesting area, as demonstrated by previous studies showing that the kits' mortality during the cold season is similar to the one of the warm season.

Key words: Rabbit, Rabbit keeping systems, Rabbit underground cell system.

INTRODUCTION

The alternative keeping system based on an underground cell connected by a tube to an external cage was developed since the first 80's by the Rabbit Unconventional Keeping Centre in Viterbo (Italy), initially 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 micro-environmental conditions when it was applied in Italy. Due to the dilution of the microbial charge in the air that avoids aerial contagion, the system set outdoors is healthy and farmers never must do pharmacological treatments with exception of vaccinations. Alternative units adopting the underground cell system are nowadays 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*., 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 be set correctly.

The underground cell system has been shown to be effective in cushioning heat stress of rabbits as assessed both empirically (Finzi *et al*., 1992a; Finzi *et al*., 1992b) and throughout specific temperature measurements (González-Redondo and Finzi, 2016). However, to date no research has been conducted to evaluate the effective thermal regime of the underground cell system during the cold season. To know these conditions is of interest because in many countries, during the cold season, rabbit kits in the nest could experience cold stress inside the underground cells. Therefore, the aim of the present study was to check the minimum temperatures reached inside two different models of the underground cell system in relationship with the outdoor temperatures during the cold season. This will provide relevant knowledge about the efficacy of this alternative rabbit keeping system in naturally modulating the cell micro-environmental temperature to protect nesting kits from cold stress.

MATERIALS AND METHODS

The trial was carried out in an alternative farm located in the Viterbo province (Italy) where the climate is subtropical Mediterranean, that is mitigated by the presence of the Mediterranean Sea. The sheltering system (Figures 1, 2 and 3) was formed by the cells that were common water draining boxes covered with earth till the upper rim and were connected by a tube to external cages (De Lazzer and Finzi, 1992; Finzi, 2004). The system simulates natural conditions and offers a sheltering preferred by does even in comparison with free ranging (Finzi *et al.*, 2001). Cells were closed by a movable insulated lid (Figure 2) that made them explorable to control the nests (Figure 3) and to be cleaned after each reproductive cycle. The does, individually housed, and the litter when grow up, could move from the cell to the cage, freely choosing the more convenient environment.

The experimental *on-farm* conditions were already described in González-Redondo and Finzi (2016). Two experimental groups were formed by six concrete and six plastic (polyethylene) underground cells, respectively. Both models of cells measured 50×50×50 cm (Figures 1 and 3). The walls of the concrete cells were 3 cm thick and those of the plastic cells were 4 mm thick.

Figure 1: Building an underground cell system. A tube is connecting cells (right) with cages (left).

Figure 2: The commercial farm in which the temperature was recorded in real field conditions.

Figure 3: A proper nest can be set in each underground cell. The passage to the cell can be seen.

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. Minima temperatures were measured every three days between mid-December 2013 and early April 2014 both outdoors and inside the cells, and the total was of 420 records in 35 days.

For each range of external minima temperatures, a) two independent samples *t*-tests were performed to compare the increase in the minimum temperature inside the concrete and plastic cells, and b) dependent *t*-test for paired samples were performed to compare the external minimum temperature and the minimum temperature inside the cells. A Pearson’s correlation coefficient between the minima external temperatures and the temperature increase (internal minus external) inside the cells was calculated. The statistical analyses were performed with SPSS v.15.0 software (SPSS Inc., Chicago, IL, USA).

RESULTS AND DISCUSSION

Figure 4 shows the minimum temperature maintained inside the underground cells when the minimum external temperature decreased from +8 to −4 ºC. The minimum temperature inside the underground cells ranged from 6.4 ºC, when the minimum external temperature was −2/−4 ºC, to 10.5 ºC when it increased to 6-8 ºC. Figure 5 shows the difference between the minimum temperature reached inside the underground cell and the minimum external temperature, for each range of minima external temperatures. The minimum temperature inside the underground cell was increased ($P<0.001$) with respect to the minimum external temperature for all the minimum temperature ranges comprised between −4 to 8 ºC. This increase in the minimum internal temperature with respect to the minimum external temperature ranged between 4.3 ºC when the minimum external temperature was 6-8 ºC to 9.4 ºC when it decreased to −2/−4 ºC. This represents a significantly negative correlation ($r = -0.643$; $P<0.001$) between the minimum external temperature and the increase in the minimum temperature inside the cells.

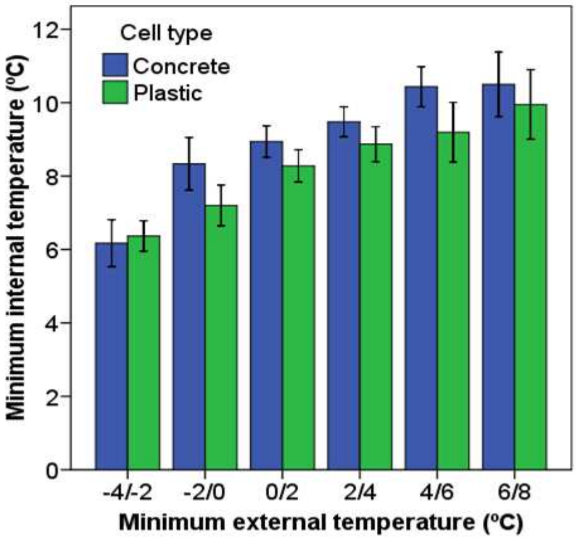

Figure 4: Trend of cells minima temperatures for increasing external minimum temperature.

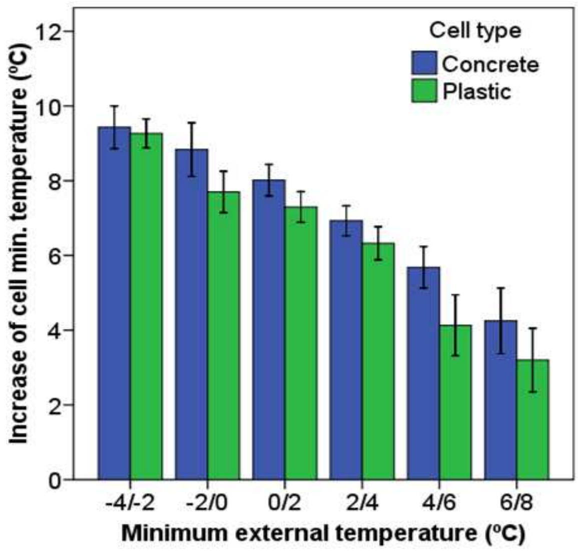

Figure 5: Difference between cells minima temperature and external minimum temperature.

These results demonstrate the relative efficiency of the underground cell in keeping the inner cell temperature under cold weather. This effect is favoured by the underground position of the cells whose heat gained during the warm hours of the day is retained by the soil in which they are embedded, as occurs in natural burrows. It must also be considered that minima temperatures are reached only for some hours of the day in which the physiological thermoregulation is necessarily involved.

For minimum external temperatures higher than −2 ºC, concrete cells produced a higher increase ($P<0.05$) than plastic cells in the minimum temperature inside the cells with respect to the minimum external temperature, which ranged between 0.6 and 1.6 °C (Figure 5). The better efficiency of the concrete structure in increasing the internal cell temperature, receiving it from the warmer surrounding ground, depended on the better thermal conductivity of concrete compared to plastic (Engineering Toolbox, 2003).

In the same way as for heat stress (González-Redondo and Finzi, 2016), the thermal efficiency of the underground cell can reduce the risk of cold stress and the reproductive seasonality in farms using this keeping system is avoided, at least in terms of the main parameters characterizing the does' reproductive performance. Specifically, the good thermal regime of the underground cell system under cold conditions agrees with the kits mortality during lactation that is not increased in the underground cell system during the cold season in comparison to the warm one, as reported previously (González-Redondo *et al*., 2008). Thus, the good thermal range of the underground cell system during the cold season must be added to its excellent efficiency during the warm season in which the maximum internal temperature was lowered by 7.6 °C in comparison with the maximum ambient temperature when it reached values of 34-35 °C that impairs the reproductive performance of does. Therefore, the cell keeps its internal temperature low when the outside temperature is high, offering self-conditioned environmental conditions that are cooler in the hot season and fit to protect rabbits from heat stress (González-Redondo *et al*., 2008).

Moreover, while the buildings used in the conventional rabbit farming, in the area considered, must necessarily be conditioned, throughout heating in the cold season and cooling in the warm one, 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).

CONCLUSIONS

In conclusion, with ambient temperatures below zero the underground cell is fit to keep its internal temperature 9-10 °C higher. With reference to the usual atmospheric temperatures in the Mediterranean area, even if, in cold weather, the plastic cell is slightly less efficient to increase the internal cell temperature, in comparison with concrete cell, nevertheless both cells allow sufficient thermal welfare conditions for kits in the nests. Therefore, where convenient for technical reasons, the lighter and more easily utilized plastic cells can be used, though costlier, without major drawbacks, mainly in developed countries. 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 or earthenware cells by themselves, manually and at low cost (Finzi, 1987).

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