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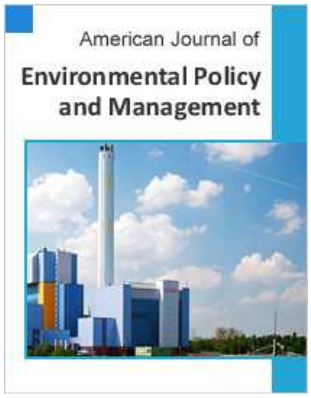

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Environment and Different Management Systems in Rabbit Does- A Review

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Abstract
Animal welfare and productivities are products of enriched housing systems integrated with their environment in rabbits' production. Housing designs that do not incorporate environmental modifications for rabbits in it can impair thermo-comfortability and some behavioural characteristics in them, especially at different seasons of the year in tropical climate. Housing systems with environment that may result in the best reproductive performance in rabbit may be complex and usually demands integrated management practices. One strategy that has attracted the interest of researchers is the use of different houses, some with automations and equipment, others with traditional/conventional cages, and improvised cages and underground shelter for rabbits' rearing. Moreover, housing and managerial systems complement one another and together with seasons of rearing may directly affect weights of rabbits, their feeding systems, their productivity and litter size at birth and at weaning. The last few years have witnessed many researches in search of efficient rearing methods via natural housing systems with environmental considerations that give higher productivity in rabbits. The aim of this review is to present some of the results of these works.

1. Introduction

The housing of rabbits is related to behavioural, hygienic, environmental and welfare aspects. Welfare in rabbits is the same as in other animals on the farm as it is measured in rabbits by same indicators used for other animals. Listed among others factors by [1] are the following indicators for rabbits' welfare:

Mortality: no or low (unavoidable) mortality;

Morbidity: pathologies (internal diseases', infectious factorial diseases); injuries e.t.c.

Physiology: hormone levels, heart rate variation, immune reactions- the physiological parameters species- specific standard,

Behaviour: ethogram, reaction to behavioural tests- species- specific behaviour and

Performance (production): growth, feed conversion, fertility rate- the performance should be on a high level.

Added to the above is:

Environmental considerations: climatic conditions of the area; integrated housing systems; dust particles in the air; management systems; husbandmen skills e.t.c. [2]

Just like all other farm animals, to reduce amount of particulate matter (PM), dust particles that can penetrate into the deeper respiratory airways, thereby compromising animals' and human's respiratory health, certain steps need to be taken [2, 3]. Housing management, husbandry techniques, feeding, rabbits' stage and some environmental parameters are some of the factors to be designed and controlled by housing systems

chosen by the farmers [2]. These factors also have significance in biochemical parameters parallel to changing physiology of the animals before and after parturition [4]. According to [1], none or low (unavoidable) mortality is the most important welfare criterion and the overall health status of the rabbits is a main welfare parameter. A review on the rabbit behaviour under modern commercial production and managerial conditions is given by [5, 6]. The parameters of performance (liveweight development, feed conversion, fertility) also belong to the welfare criteria. A high performance is no proof for a high welfare level, however, a low performance is an indicator for problems in housing, environment and management. They are sensitive to environmental factors and those who respect this fact [7]. Therefore, according to [8] and [9], housing of rabbits in conformity with animal welfare and protection means (i) not more than unavoidable mortality; (ii) uninjured body; (iii) good health condition (not more than unavoidable treatments), (iv) species- specific behaviour and (v) development of animals corresponding to age and sex.

Upon all, [10] listed the followings as general requirements for housing of rabbits:

-no pain, no avoidable sufferings and no injuries caused by housing (floor, walls and edges),

-protection against predators, ectoparasites and endoparasites,

-provision of feed and water corresponding with the need of rabbits (*ad-libitum*),

-protection against adverse climatic conditions,

- removal of gases, dust and pathogenic germs from the rabbit house,

-a good handling of animals (safe and quick catching – no frightening, no injuries),

-separation of rabbits from their excrements by using perforated floors if possible (in the intensive housing),

-from time to time use of "all in – all out" with cleaning and disinfection, and

-enriched housing system – e.g. 2nd floor/elevated platform for the rabbits.

Environment, shapes and orientations of building greatly influence air movement into and around it and account for increase or decrease in heat and its accompanying stress in stocked rabbits [2]. However, a small change in both building form and shape or feature arrangement may create large changes in air movement [2]. Improvement of rabbits' living conditions and their welfare is to ameliorate husbandry conditions by enriching their environment [11]. Environmental enrichment is any modification in the environment of captive animals that seeks to enhance its physical and psychological well-being by providing stimuli meeting the animals' species and specific needs [12].

When rabbits are considered biologically, there are some behavioural characteristics in them that are governed by the design of their housing just as they react to environmental temperature and humidity. For instance, their territorial behavior, which is apparently not too different from their wild counterpart, their social, maternal, sexual and feeding behaviours are all affected by sex, husbandmen behaviour, their housing systems and their environment. If, however, due to poor design and the environment cannot be modified through housing type for rabbits, which may result into air movements not reaching deep down into building's space [13], then rabbits' behaviours/welfare will be impaired. The objective of this paper is review different housing systems and their effects on rabbits' rearing, indicating their potential and limitations and the type that give higher productivity in rabbits.

2. Different Housing Systems for Rearing Rabbits

It is a known phenomenon that housing for rabbits in the tropical regions is different from housing design for the same animals in the temperate countries. For instance, the TOTAL square foot area of the inlet air should be slightly less than the TOTAL square foot area of the outlet in the temperate [14]. It is the opposite in the tropics, the outlet area being larger will work to remove hot air faster. If the total square foot area of inlet is more than the outlet, air will move much more slowly or not at all on calm days.

2.1. Conventional

The conventional rabbits' houses include thatch roofed and tile roofed houses that are still in existence in local areas of some African countries like Nigeria and in India [2] and [15]. They are of various dimensions and size allowing 0.28 – 1.32 m^2 per adult rabbit. The need for improvement in housing was felt when farmers started recognising rabbit meat as one of the good quality meat. Sheds were used as improvised housing giving 0.6 - 1.0 m side wall on two sides (length wise) and a complete wall on eastern and western sides to bear the weight of the roof [2 and 15].

2.2. Cage

In some regions of the world, cages (or hutches) are used; these may be cages with straw litter or may be cages without litter. Traditional European rabbitries use straw litter. In such case, such material can be replaced by any other dry fibrous product which is not rough to the touch (soft shavings, hay, industrial cotton waste are used) [16]. The greatest disadvantage of the cage system is that rabbits are exposed to high temperatures during the hot season. High temperature also affect growing rabbits negatively due to reduced rates of liveweight gain caused by reduction in feed intake [17]. The impact of temperature on rabbits has been studied by various authors. It was also reported by [18] that high temperature affects spermatogenesis, reducing the volume and concentration of ejaculates and also affects sperm motility after 8 hours at 36^{o}C or 14 days at 30^{o}C.

2.3. Free Range

This system is conspicuously the most simple because it gives the rabbit all the freedom it can have except that its movement has limit within the fence, nevertheless, it still has its natural living conditions. How is it done? In a small group (1 buck and 3 -5 does) the rabbits will reproduce without leaving the area if feed and water are regularly supplied and they are kept under control by some form of periphery fence.

2.4. Underground Shelter

This is based on the fact that rabbits under natural conditions live in underground "burrows" dug out from the soil. The rabbits have advantage of moving in and out (according to the climatic conditions) of the burrows they made naturally for themselves. For them to make such underground burrows, farmers may facilitate it by making heap of sand of about 0.5 m high, it may be of brick or clay heap. They will modify their shelter by digging to enlarge/lengthen their burrows and undergo their parturitions there. The question is which type of rabbit will be kept in this underground shelter? The wild or standard breed or heterogeneous breed or what? It has been observed that any of the above breeds will naturally dig underground burrows to live therein if freely reared as in free range system in a fenced area [2]. Only that any of these mentioned breed had characteristics of wild rabbit with time.

2.5. Modern Houses

It should be remembered that in all these housing systems specified above, the modern concept in housing started with elevated or raised platform which has the following advantages: good light/brightness; good ventilation; ammonia free air and clean indoor atmosphere. Modern systems include the use of cages inside the shed building of wall 0.8-1.0 m high all around the edge with wire-net covering [2, 7, 10, 12]. In all the housing systems, to avoid the problems of changing litter (where we have litter), rabbits are separated from their excrement as soon as this is dropped. They are raised above the ground on a wire mesh or slatted floor. Such wire mesh floors are always thick enough so as not to injure the pads of the rabbits' feet, usually diameter 2.5 mm or minimum of 2 mm is used.

2.6. Modern House in Temperate, Sub-tropics and Tropical Regions

Modern houses for rearing rabbits in temperate regions may be complete with wall at all sides, with eave and ridge openings or sometimes with chimney to heat the house in winter. This may not be so in the tropical or sub-tropics, sheds with 0.8-1.0 m all-round are used as improvised housing. Large floor-to-ceiling openings are alright for optimum ventilation provided the openings in the opposite walls are not at high wall level, otherwise, no appreciable ventilation or air movement at the lower level.

2.7. Group-Housing of Rabbits and Individual Housing Systems

This is a modern system of housing rabbit for space and cost economies and management. They may be made up in each case, of plastic mesh floor, elevated platform, larger cages, foot mats for the rabbit does e.t.c. Some of these materials may increase the production costs, but also improve the welfare of animals and may at times provide larger area of activity and incidence of behavioural stereotypes [19, 20].

In all these housing types, there are various forms of openings (namely inlet and outlet openings, edge and eave openings) and also the building may be oriented towards a known wind direction. Placement of openings in relation to one another and the orientation of the openings to the direction of airflow may create positive and or negative results [2, 13]. No matter what and wherever they are designed in rabbits' building, openings or orientations have their specific functions and upon these housing's effectiveness can be evaluated [2]. Focusing on production and some welfare aspects of group and individual housing systems for rabbit does, [19] found out that group-housing of does, independently of larger area for moving and social contact, contravenes the welfare recommendations, this resulting in chronic stress, aggressiveness and injuries, higher risk of diseases and mortality e.t.c. They found out that their reproductive performance was lower and the costs of production were higher. They reasoned that group-housing systems do not fully meet the needs of the animals and they negatively impact the rabbits' well-being since they have less space to move and less opportunity for social interactions. They concluded that individual housing of does in enlarged and enriched cages currently best meets the demands of rabbits, farmers and consumers.

3. Evaluation of Building Openings' Effectiveness, E

According to [21], effectiveness of the building openings (E) varies according to direction of the wind relative to the opening and is given as:

$$E = 16.33\left[\frac{0.21\rho v}{\mu}\right] \text{-}0.3515 \text{ x } \text{Sin}(\phi)1.201 \text{ x } \left(\frac{4z}{l}\right) \text{-}$$
$$0.1213 \text{ x } (\text{Sin } \theta)\text{-}0.1531$$

where

E = opening effectiveness, dimensionless

ρ = air density / (kg/m^3) = 1.65 kg/m^3 at 30 ^oC

v = air velocity, m/s

μ = absolute air viscosity Ns/m^2 = 0.0000248 Ns/m^2 at 30 ^oC

ϕ = wind flow angle of incidence, degrees

z / l = ratio of opening height to opening length, dimensionless

θ = roof slope, degrees

From above equation, E is a function of building parameters, thus the conditions of the house interior depend solely on the E and by extension the rabbits' welfare depend on E of a building.

4. Effects of Housing Types on Some Climatic Parameters and Rabbits Movement Within Their House

Since the underground shelters allow the rabbit to move about in their restricted-fenced plots, thereby receiving all what wild rabbits could also receive within their place. The free range system may be likened to it in that their rabbits will also have the same temperature and humidities of their surroundings. Thus they may be inferred to have temperatures lower than those in cages and higher humidities than those in cages for higher survival.

In their experiment, [15], where conventional housing (ground level house) and improvised shed building (elevated or raised platform) were used for rearing broiler rabbits in India. They found out that temperature was lower in ground level house than in improvised, raised platform house. They reasoned that, although there was tile roof, the advantage of green cover around the shed and earthen floor helped to keep the temperature lower than in raised platform. This may support earlier experiment in [17] that underground shelter (in [15]), ground level) had lower temperature, higher humidity than cage (raised platform).

The implications of these are that rabbits reared in raised platform may have higher temperatures, lower humidities than those raised on the ground- 100% earthen floor. Unlike in the raised floor for rabbits' rearing where there was a result of significance, [15] obtained no significant difference between the temperatures in outdoor and indoor in the earthen- ground floor shed. However they had significance between humidities (at forenoon and afternoon) and between air velocities also at forenoon and afternoon period in all cases at outdoor and indoor in both sheds as reported by [22].

5. Effects of Different Housing Types on Some Reproductive Parameters in Rabbits

The cumulative effects of different systems of housing on liveweights, litter size, conception rate and gestation period among others reproductive parameters in does when such house is integrated with the environment are discussed below.

5.1. Effects of Housing Types on Body Weights and Weight Gains

For the cages/pens housing of broiler rabbits or rabbit does in a tropical and sub-tropical climates. Higher weight gain was recorded at rainy season due to lower temperatures and higher humidities in pens as reported by [2]. For temperate regions, there were no differences in body weight, weight gain and slaughter performance of rabbits housed on plastic- or wire-mesh floors as reported by [23]. Body weights of rabbits between the ages of 7 and 10 weeks were significantly higher in the group on wire-mesh and plastic-mesh compared to the rabbits on deep-litter [24, 23]. However, the 12 weeks-old rabbits showed no significant differences among groups. The body weights of rabbits between the ages 7 to 10 weeks were significantly higher in the group on the wire-mesh and plastic-mesh compared to the rabbits on deep-litter [25]. Cage floor type had no significant effect on the final body weight but daily weight gain (at 6-7 weeks of age) for rabbits reared in cages with wire mesh floor was significantly higher than those reared in cages with plastic and rubber mat floor [26].

5.2. Effects of Housing Types on Conception Rate and Gestation Period

Also, [27] reported that the rabbits in their individual pens in Egypt have longest gestation period in summer (high temperature) and [28] showed that in Egypt, conception rate was lower in hot summer than in winter by 76.8%. In Nigeria, for all services at % pregnancies for group of rabbits, conception rate was lower in rain than in dry season by 16.55% [2], this was in contrast to what had earlier been found by [29, 30] that conception rate increase in the summer than in the winter (in the temperate regions) for does in cages. Again, [2] found out that in the rainy season in Nigeria, a tropical climate, productivity of rabbit does, (P) was high; 446.94 and 399.76 for 80% opening at 45^{o} and 90^{o} orientations respectively.

5.3. Effects of Housing Types on Litter Size

Comparing the rabbits housed in the underground shelters with those housed in the cages in Vietnam, [17] said that does in underground shelters were 8% heavier after two months of rearing and that they gave birth to 39% more litters and weaned 60% more litters than those in cages. They further found out that litters' survival rate from birth to weaning was improved by 10%. Moreover, for broiler rabbits, [17] found out that the rabbits in underground shelters were 17% heavier after 1 month and 19% heavier after 3 months with the average growth rates that were 20% greater. All these could have been so probably because of the ambient temperature that was lower on average by $3.8^{o}C$ and average humidity that was higher by 4.75% within 10-day period in July in Vietnam. Upon these, they concluded that underground shelters for rabbits' rearing could be markedly superior to the conventional cage system in North Vietnam.

6. Conclusion

As advantageous as raised-up-from-ground floor houses for rabbit is over underground shelters common to wild rabbits in terms of good light/brightness; good ventilation; ammonia free air and clean indoor atmosphere, it has to be

well designed for enrichment. This is because different housing systems have different effects on rabbits' rearing; they affect their potentials and limitations, welfare and productivity. There are some characteristics in rabbits that may be affected by some design criteria of their houses just as they react to some environmental parameters and thereby yielding positively to the environmental enrichments provided by the farmers in their building.

Each of the tropical or sub-tropics or temperate regions has to be with a peculiar structure for effective and efficient rabbits' production. Different ways are needed not only on design but also on the animal number to be kept per pen/cage and the nature of the pen/cage's flooring. Group-housing systems do not fully meet the needs of the animals and they negatively impact the rabbits' well-being since they have less space to move and less opportunity for behavioural/territorial characteristics, individual housing of does in enlarged and enriched cages meets the demands of rabbits' rearing for high productivities.

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