Tropical and Subtropical Agroecosystems

REVIEW [REVISIÓN]

REPLACEMENT IN RABBIT HERDS

[REMPLAZO EN HATOS DE CONEJOS]

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SUMMARY

Doe rabbit's replacement refers to the annual renewal rate of new breeders that must be incorporated into the production stock. Criterion for culling non-productive animals differs significantly among fryer production colonies, foundation stocks and a colony with continuous enzootic disease or continuous malnourishment. In commercial rabbit production, good management improves the health and productivity of the entire herd, by reducing the all-time high replacement rates and improving economic viability. In the present article, a comprehensive review of numerous experiences in the rabbit production field of different countries, was presented. Basic recommendations for professional breeders were highlighted, covering critical issues such as the need for continuously upgrading the health status of the colony, the positive effect of genetic selection and the nutritional conditioning and special treatment of young does being groomed as future replacements.

Key words: culling; raising replacements; replacement rate; viability; welfare.

RESUMEN

El reemplazo de conejas se refiere a la tasa anual de renovación de hembras que deben incorporadas al hato reproductor. El criterio de desecho de animales no productivos difiere para los animales de engorda, progenitores y/o grupos de animales con enfermedades enzooticas o desnutrición continua. En la producción comercial de conejos, el manejo adecuado mejora la salud y productividad del hato al reducir las altas tasas de reemplazo y mejorar la viabilidad económica de la producción. En el presente trabajo se revisa la experiencia productiva de varios países. Se remarcan recomendaciones básicas para los criadores que cubren aspectos críticos tales como la necesidad de mejorar de manera continua el estado sanitario de las colonias, los aspectos positivos de la selección genética y condición nutricional así como los cuidados especiales para las hembras jóvenes que son criadas para ser reemplazos.

Palabras clave: Desecho; crianza de reemplazos; tasa de remplazo; viabilidad; bienestar.

INTRODUCTION

Rabbit breeders in major producing countries face increasingly difficult economic situations, with gradually falling sale prices and generally rising feed prices, after the initial establishment of rabbit production.

In this respect, a major mistake in rabbitries has been to strive only for high production and bring in as many replacements as needed (Paillole, 1986), regardless of the intrinsic elevated cost of large cullings. Besides that, this might be carried out without making the health of the herd the top priority, which allows the resulting healthy edge of the stock move forward to attain better prolificacy and a higher fryer output, closely dependant of health status.

These external economic difficulties compound the internal work load that managers face, to maintain stock health and productivity.

In the present article, a comprehensive review of replacement in rabbit herds is presented, highlighting numerous experiences of different countries and basic recommendations for professional breeders covering critical issues in the rabbit production field.

ECONOMICAL BACKGROUND

The European Community production of rabbit has fallen steadily by an average of 0.69% per year and consumption per capita diminished by an average of 1% per year, during 1989 - 1995 (Alvarez de la Puente, 1996).

In Spain, the average price decreased from 1990 to 1994 in Belipuig, the most significant bourse (Rafel *et al*., 1996). This was due to that there were no technical improvements available to increase the productivity per cage or improve the genetic quality of the animals to offset the falling sale price (Rafel Guarro, 1996).

In France, during a similar period, breeders were able to increase production per cage and improve work organization to balance the effect of falling sale prices (Rafel Guarro, 1996), by increasing the normal work-load of caretakers for the same wages. Similarly, profit minus cost of feed per doe's cage increased by 17%, during the previous period (1986 to 1990) (Koehl, 1991). But these results were achieved by increasing the number of does kept per maternity cage from 1.19 to 1.35 on an average, resulting in an increase of 13%, in which the rise of income mainly resulted from a certain knack and only to a small extent was accounted for by an increase of real animal performance. In other words, in France, the rabbit sector was holding a leading position and there was a large scope and high level of research and considerable effort in advising both officially and privately. However, the amount of management errors seemed to have remained unchanged and practically, one can presume the situation being no better in other countries.

In the USA, Patton (1988) reported that there were only a few production units working profitably and he expected that most of these units will be in business no longer than three years. The reason for their failure is believed to be that they started investing a considerable amount of money, while using faulty management. It is considered that this mismanagement arises from the practice of attempting to transfer early personal experiences of keeping rabbits as a hobby to a big commercial operation.

In Great Britain, similar trends were reported (Schlolaut, 1992).

The above information may indicate that the high rate of losses in young rabbits and the high replacement rate of does during the past two decades suggest that knowledge gained has led to hardly any changes in producing operations. This goes for matters of veterinary medicine, feeding, husbandry and genetic improvement of viability as well. Also, it could be stated that improvement in management could compensate the decline in productivity by losses and infertility to a large extent (Schlolaut, 1992).

THE HIGH LOSSES IN RABBIT PRODUCTION

Losses of young and doe rabbits were reported to be extraordinarily high (Schlolaut, 1988) and remained so until today, in most countries. Mortality of young rabbits from birth until slaughter was 33.4%, as well as, 143% of the does caged per year had to be replaced, meaning that the breeding stock, as a rule, does not survive its first year of production. Studies in Spain showed that yearly mortalities of does were 35.0 and 46.7% on average in 33 and 11 operations, respectively (Iruretagoyena, 1991). Similarly, Henaff (1987) recorded a slight rise rather than decline in mortalities of young animals, when compared to recent ones. However, under all cases, it should be kept in mind that mortality numbers in young and doe rabbits out of the institutions are six to eight times as high as the numbers found under institutional conditions. At the same time, these considerable losses in commercial rabbitries were several times higher than in other livestock species (e.g. poultry, pigs or cattle). However, the high rate of losses apparently is not a specific phenomenon of the rabbit, but it is due to the consequence of flaws in management. In this respect, the commercial rabbit production still remains in the initial state of its development (Schlolaut, 1992), while the rabbit has to compete with such species for market share.

DISEASE

Although many factors determine the level of rabbit losses, the most important aspect encountered is disease, singled out as a product of the environment (natural plus human management) in which the animal lives (Coudert, 1992). Such variable has a negative impact leading to a high replacement rate, reducing income and increasing regular maintenance costs due to expenses related to drugs and chemicals used for morbidity control, specially when early losses of successfully producing dams were due to outbreaks of disease and other problems.

In suckling rabbits

In suckling rabbits (Table 1), the losses until weaning reported in Spain, were mainly caused by staphylococcal infections and diarrhoea which were largely the result of faulty hygiene (Rosell *et al*., 1991). In the same country, the health disorders reported during the period of 1989-1995, were: digestive disorders, respiratory problems and other deaths from miscellaneous or unknown problems (Rosell, 1996).

In weaned rabbits

In weaned rabbits (Table 1), deaths reported in Spain during the period of 1989-1995, were associated with intestinal disease, respiratory lesions, and other conditions (Rosell, 1996).

The viability of the young was also affected by disease problems in the dams, since Scheele and Bolder (1987) found a relationship of young animal losses to the state of the does' health.

In replacement does

In replacement does (Table 1), young virgin females were necropsied during the period of 1989-1995, with ages between 2.5 and 4.5 months. Of these animals, 58% had a respiratory disorder, 18% Viral haemorrhagic disease (RHD), enteritis-diarrhoea 16% and 8% unknown causes. This description highlights that under such level of disease, it is difficult to produce replacement stock in such an environment (Rosell, 1996).

In dams

The causes of dam's culling were classified into five categories (Sanchez *et al.*, 1985): 1. Poor production of dams as judged by: severe weight loss, failure to raise a litter to weaning age on two consecutive kindlings, failure to accept service for 14 consecutive days or failing pregnancy after three consecutive matings (this concept of failure to conceive must now be adjusted according to recent research on pseudopregnancy), 2. Bacterial respiratory problems, 3. Mastitis or other abscesses non-responsive to treatment with antibiotic for three consecutive days, 4. Pododermatitis (sore hocks) and 5. Other causes including enteric disorders, infection of reproductive tract, broken back, eye infections and hereditary alocclusion.

During the first three litters, Rastogi (1988) reported that culling of dams was due to poor performance as old age and difficult breeding (Table 1). However, the poor performance may be the product of inadequate feeding and management deficiencies. As well, kit performance was so poor that the prospect of raising a suitable replacement doe was bleak.

Over seven selected generations of does, culling percentages were higher in healthy than in sick females. The major cause in other reasons was related to reproductive problems culling and death, followed by respiratory process culling death (Table 1). The reproductive problems were refusal to mate, infertile does, abortions, mummified foetus, etc (Canet *et al*., 2000).

Diseased breeding dams percentages culled in three groups of New Zealand White (NZW) rabbits fed three rations with different percentages of crude protein being 17.5, 19.0 or 20.5%, were found to be, respectively, 8.0, 25.0 and 17.2% due to respiratory problems, 12.0, 7.1 and 6.9% due to mastitis, 12.0, 7.1 and 3.5% due to pododermatitis, 8.0, 3.6 and 10.3% due to combined causes, 24.0, 32.2 and 20.7% due to death and 16.0, 7.1 and 6.9% due to other causes (Sanchez *et al.*, 1985). However, in this study it was commented that the numbers of does replaced were low (25, 28, 29, respectively) and the protein to energy ratio in the Oregon diet used was high.

Categories of losses of does at 321 commercial rabbitries in Spain were reported to be, respectively: respiratory disease, reproductive disease including metritis, pyometra, foetal mummification, mastitis, pregnancy toxaemia and uterine torsion; enteropathy, viral haemorrhagic disease (RHD) and miscellaneous or unknown diseases, during the period of 1989-1995 (Rosell, 1996, (Table 1).

Asteurellosis was also described as one of the biggest disease problems of rabbits in some of the most devastating clinical forms (respiratory, systemic and reproductive presentations), followed by enteritis and vitamin A deficiency or toxicity. Signs of deficiency or toxicity are similar. Both include decreased conception, abortion, small litter size at birth, neonatal hydrocephalus (oversized head), drooping ears in young rabbits and increased enteritis (Tena *et al*., 1984; Patton, 1991).

In an epidemiological study carried out on rhinitis in adult domesticated rabbit of 4719 females examined in 94 commercial rabbitries and 1241 males examined at 84 units, over a two-year period in 1992-1993, showed high prevalence of rhinitis in bucks than in females and that 50% of the dams died or were eliminated after the fourth kindling, when considering the same age. Another objective of this study was to estimate the percentage of sick does according to the number of parity, which was higher at the third parity and without meaningful significance during the phase of lactation (Rosell *et al*., 1996).

The short life expectancy is also obviously related to health problems in doe populations. Detailed data on the causes, based on a production analysis of three Italian breeder's stocks having a total of 3140 doe cages showed that doe mortality was with a range of variation between 26 and 55% (average was 36%) per year. Another 50% of the does were culled for reasons of disease and unsatisfactory performance. Thus, only 14% of the does lived longer than 1 year (Lukefahr *et al*., 1980, Table 1).

Percentages of doe mortality (including culling or death due to snuffles) were found to be the greatest, respectively, for Flemish Giant and NZW compared to Florida White x NZW hybrid dams (Lukefahr *et al*., 1980). However, another study showed that doe mortality was very high in several rabbit breeds [NZW, Californian (Cal), Checkered Giant and Flemish Giant], perhaps indicating an environmental problem. Doe loss was 44.4% due to death at an average age of 17.2 months, mostly as sudden doe death syndrome (Rastogi, 1988).

ASSESSMENT OF DOE PRODUCTIVITY

In rabbit production, sound studies regarding productivity per doe cage or per animal and the economic conclusions derived, may help in the recognition and correction of management errors. However, such studies are rather obscure due to early replacement of does that leave production.

Efficiency of productivity should be related to each and every animal housed as it occurs in poultry and pigs. In addition, it would be desirable stating the range of variations of the results in different operations, together with breeding animals' origin (population and breeder).

Productivity assessment is usually evaluated following the third parity. Dams that are characterized by constantly kindling less than six live young or have litters with a high number born alive but have excess losses before weaning, should be retired from the herd. Sterile rabbits (although it is not common), aged dams that produce less than 20-25 kits per year in intensive breeding systems and those that show disease, also should be culled (Patton, 1988).

Reviews of research reports show that doe litter traits have low to moderate repeatability, i.e. doe performance is affected by permanent environmental conditions that may be different from parity to parity. Thus, selective killing of does as a consequence of one or two poor litters is unjustifiable. At the same time, culling of any doe must be based on records of several parities and ranking of this doe compared to the average of all does (Srensen *et al*., 2001). For instance, if the efficiency of the entire herd is below an acceptable level, the health and condition of the entire herd must be improved. Lukefahr (1988) defined the base line for culling level for fryer production of a doe as being below 80% conception rate, below 5 kits born (more than once) and below 60% of kit survival rate. This culling criterion is based on abstract notions unrelated to herd average production or environmental conditions.

From an economic point of view, the closer the percentage of the number of the breeding dams producing a profit relatively to all breeding dams in the herd to 100, the closer the rabbit operation comes to maximizing income. However, many European systems base the replacement rate on the number of maternity cages instead of the actual number of productive dams (Mckroskey, 1997). Rommers *et al*. (1999) indicated that optimal fryer production should be achieved from thrifty parental animals which produce at least 45 kits per year in uniform litters with good mass. Such litters would be characterized by a litter size of at least 7 kits with a minimum mass of 60 g at birth and 320 g at three weeks (three-weeks mass gives a good indication of milking ability) and 1.8 kg at eight weeks of age.

However, although these statistics are suggested as standards for fryer production for most breeding operations, it would be ideal for fryer selection for replacement stock.

CULLING AND REPLACEMENT RATE

Many rabbit raisers are more concerned with increasing the number of dams in production than in improving the level of production of the average doe. This position is often achieved by a failure to cull poorly producing dams and contributes more to the demise of rabbit farms than any other single factor. Practically, in order to maintain profitability and health of the herd, dams which are below average production should be culled as soon as a replacement is available.

Donal (1973) concluded that culling rate in commercial farms depended on the average farm production, parity and cost of doe replacement. Of course this is assuming a true production herd in which disease is not a major factor. This is quite different from the frequently seen situation of a barn full of animals with various disease problems.

Replacement rate is the annual renewal rate of doe rabbits in order to replace culls. Replacing a sizeable portion of the breeding stock yearly is important to improve the quality and health of the herd. The optimum replacement rate was estimated at 25 to 35% for the productive dams by Walsingham *et al*. (1977) and at 100 to 125% of the breeding rabbit dams each year in commercial rabbitries by Cheeke *et al*. (1987). In modern rabbit production systems, the rate of replacement is around 120% per year. However, replacement rate was estimated to be 163% by Hameury (1988), 160% by Koehl (1988), 70% by Finzi (1992) and between 102 and 140% with an average of 121% by the Research Official Organizations in France (1995, 1996). The differences in replacement rate among the different studies of the literature reviewed, may be attributed to disparities in the breeding systems and the environmental conditions that prevailed in each study.

High replacement rates will inevitably slow down progress of performance based on heredity, together with limiting of selection intensity.

Does which have to be kept in order to compensate losses require additional housing capacity, which lowers the return on investment. In the report by Schlolaut (1992), profits were shown to be reducing by 28% between 1983 and 1990. Continuous replacing of high losses may deteriorate hygienic conditions that will add to higher mortality. In order to reduce this risk, some breeding units hand over replacements for alien doe stock at an age of 2-3 days, to be reared by does in the new unit (Schlolaut, 1992).

FACTORS AFFECTING REPLACEMENT RATE

Regarding the effect of parity, Askar (1998) reported that replacement rate (RR) during the second kindling year (KY) was lower ($P<0.001$) than that of the first one (106.7 and 86.8%, respectively). The decrease in replacement rate during the second KY may be attributed to the increase of percentage of good dams in the second KY over that in the first one, as an effect of selection. The causes of culling during the first and second kindling years, were mainly due to death and pathological causes, respectively (Lukefahr *et al*., 1980; Patton and Cheeke, 1980; Sanchez *et al*., 1985; Rastogi, 1988; Patton, 1991; Askar, 1998).

Due to the level of kits produced, the replacement rates were estimated as 80, 100, 120, 140 or 160% if the breeder aimed to produce 35, 40, 45, 50 or 55 kits per maternity cage per year, respectively (Research Official Organizations in Spain, 1997).

Replacement rate was found to increase gradually with the increase of litter size at birth up to 7-8 kits (17.8%) and remained around this level thereafter. This trend may be due to the high percentages of culling due to death and pathological reasons in dams (5.6 and 8.1%, respectively (Askar, 1998) and particularly to high preweaning mortality (Broeck and Lampo, 1975; El-Maghawry *et al*., 1988; Askar, 1989).

Dams of medium mass (3.0 - 4.0 kg) showed lower percentages of replacement rate than those of lower or higher mass due to their better health conditions and their better productive performance (Askar, 1998), as well as the abnormal physical conditions of too thin or too fat dams (Cheeke *et al*., 1987). However, several factors can affect doe's mass, such as decrease of feed intake or overfeeding and high frequency of pregnancy.

Such stress conditions may lead to lower resistance to disease (natural defense mechanisms) due to the increase of the dams susceptibility to infection with diseases, especially during pregnancy, parturition or suckling periods. Dams of the lowest mass (<3.0 kg) showed the highest percentage of culling due to death (10.9%), in comparison with those of other mass values (ranged between 2.7 and 3.8%; Askar, 1998). Askar (1998) concluded that the ideal doe mass is between 3.0 - 4.0 kg in Egypt, while it is higher in European countries, e.g. between 4.3 - 4.7 kg in Italy (ANCI, 1990).

Season of the year affects replacement rate. Marai *et al*. (1996, 2000) and Ayyat and Marai (1998) showed that mortality rate increased significantly under high temperature conditions, which may suggest a better selection of dams in subtropical areas on the basis of their reproductive efficiency during the hot seasons of the year. However, Askar (1998) found that the effect of the year season on replacement rate was not significant.

Lukefahr *et al*. (1980), Patton and Cheeke (1980), Rastogi (1988) and Patton (1991) attributed the high RR in rabbit herds to young doe syndrome (i.e. sudden mortality), pasteurellosis (i.e. respiratory problems), enteritis and poor performance during the first three litters.

IMPROVEMENT OF THE MANAGERIAL CONDITIONS FOR WORKING DOES

Rabbits in production suffer from a number of different problems and many are the direct result of ill-implemented management decisions. For this reason, it is important to understand that there are two areas of interest affecting replacement rate: one is improving the condition of the doe during her life in fryer production and the second is related to the adequate preparation of the dams intended for fryer production, during the time of being raised as replacements. All does in production were once raised as replacements.

In industrial practice, the doe in fryer production is in a work environment consisting of a 42 day reproductive cycle, high replacement rate, short reproductive life, inadequate nutrition to support such intensive breeding and the intensive use of medications. She is expected to produce well under these conditions and is culled when she is no longer able to carry the load, concluding that besides the aspect of animal welfare, profitability is also affected by high replacement rates.

Table 1. Percentages of deaths due to diseases in young rabbits and doe rabbits.

Disease	Country	Period of study	Infection (%)	Culling (%)	Death (%)	References
In young rabbits						
In suckling rabbits						
Digestive disorders	Spain	1989-1995			77.6	Rosell (1996)
Respiratory problems					8.0	
Unknown problems					15.6	
In weaned rabbits						
Intestinal diseases		1989-1995			57.9	
Respiratory lesions					30.9	
RHD*					7.4	
Other conditions					11.7	
In replacement does						
Respiratory disorder		1989-1995			57.9	
7 RHD					18.4	
6 Enteritis-diarrhoea					15.8	
3 Unknown causes					7.9	
In doe rabbits						
During the first three litters						
Poor performance				33.3		Rastogi (1988)
Old age					13.3	
Over seven selected generations						
Healthy animals		1992 to 1998		49.0		Canet *et al.* (2000)
Sick animals				33.0		
Reproductive problems				14.8	4.9	
Respiratory process				6.6	4	
Commercial rabbitries						
Respiratory diseases	Spain	1989-1995			30.0	Rosell (1996)
Reproductive diseases					27.5	
Enteropathy					17.0	
RHD*					14.3	
Unknown diseases					11.0	
Rhinitis						
Bucks		1992-1993	42.9			
Females			31.0			
Three Italian breeder's stocks						
Mortality					36 / year	Lukefahr *et al.* (1980)
Disease and unsatisfactory performance			50.0			
Snuffles						
Flemish Giant					54.5	
NZW**					50.0	
Florida White x NZW hybrid					16.7	
Age						
17.2 months in average					44.4	Rastogi (1988)

* Viral haemorrhagic disease. ** New Zealand White dams.

The 42 day reproduction cycle consists of re-breeding in the range of 9 to 12 d post partum (pp) or 11 d re-breed on AI (11 plus 31 days of gestation time = 42 which is divisible by 7). Re-breeding at 9 to 12 d post partum can be an acceptable practice, if the doe is in acceptable condition, at normal body weight, receptive, and such scheduling is intended for fryer rabbit production, not for producing replacement stock.

One indicator of health status of the doe is that the doe is receptive. Use of AI ignores the health status and can cause does which do not demonstrate signs of receptivity to become pregnant. With natural mating in a non-synchronized herd, a rabbitry manager will find every day that at least 3% of the doe herd is highly receptive by vulva signs. The manager must find a way to either locate them readily, or predict the time to find them and be willing to breed them while the signs are present, since the duration of receptivity can be just a matter of hours, on a cycle of 5 to 7 days (Cudnovskii, 1957) and visible signs of receptivity on day 9 post partum could be gone by day 11 (Maertens *et al*., 2000).

Breeding this receptive 3% of the herd each day is enough to maintain good productivity. Performing some breeding each day also reduces the number of bucks required, but this type of management is more difficult to learn than following the list of daily chores in the band system. As soon as some modulating factor to band system scheduling is applied, does need to be re-bred at times which are more difficult to synchronize, which disrupts the band system of work organization. But even in the band system, there are out-of-cycle does that have failed ovulation and pregnancy tests, developed pseudopregnancies or absorbed their litters, and of these, the viable dams are added to the list of open does and placed in a non-cycling barn. Does can fail to have receptivity cycles for a variety of reasons, including such rarely reported events as foetal mummifications and ectopic pregnancies, conditions severely interfering with normal reproduction (Tena *et al*., 1991).

The use of medications on non-receptive does to force the doe to become pregnant is a necessity in "Industrial" production or "intensive breeding", giving a significant increase in performance in non-receptive does (Alabiso *et al*., 1996; Castellini, 1996).

In recent years various attempts are being made to reduce exogenous hormone use in synchronizing mating for AI, such as the use of various biostimulators. As well, primiparous does could be re-inseminated on a more extensive rhythm, or alternatively, their litter size could be reduced. Non-receptivity arises mainly during lactation, but in spite of the doe's biological imperative to reproduce, she is non-receptive for various reasons, including pseudopregnancy, which need to be addressed. In addition, the present formulations for doe feeding do not meet the full dietary needs of combined lactation and gestation (Xiccato, 1996). Gomez and Blasco (1992) showed in a study of growth curves, that adult weight had not yet been reached at 50 weeks of age, although an even longer period of time would be needed to make sure that the weight does not change in adult animals. Similarly, the young doe's nutritive requirements remain unsatisfied even if particular feeding programs are adopted. As a consequence, the future reproductive activity could be negatively affected and the female could present, during her reproductive life, worse health and poorer performance indicating that the animals are not coping with the conditions of their containment. However, Mckroskey (1997) described that individual tracking of does is desirable, and becomes feasible with modern computers that tend to improve record keeping systems in such way that some modulating system can be easily applied to production systems, such as considering weight and condition of each doe prior to breeding.

Having to cull a doe represents a reduction in her useful reproductive life. In The Netherlands in 1997, the high replacement rate (160%) resulted in the doe being replaced after 4.4 litters and 50% of the young dams were replaced before their third litter (Rommers *et al*., 1999). Other studies have also shown that rabbits have a short useful reproductive life. Bieniek *et al*. (2001) reported that in Poland, the average female gave not more than three litters with maximum number of 10 (Cal) and 8 (NZW) litters per female. Average lifetime production was 28 born and 25 weaned progeny. Average breeding period from first mating to last litter was about 13 months, with total life-time at the farm about 2 years. However, such results are not demonstrating the genetic potential of these breeds. In a Canadian production herd, the best doe gave 5.8 litters per year on an average 63-day production cycle, lived 4.65 years, kindled 25 litters with 214 born and 203 live at three weeks of age, and 47 kits reaching three weeks of age per year of productive life, demonstrating that prolonging a doe's life is both an economic and welfare issue (Rommers *et al*., 1999).

Animal welfare status includes the ease or difficulty of coping and its effects on behaviour, physiology and health status, which may also have consequences on the quantity and quality of production performance (Verga, 2000). In addition, the concepts of a "natural" meat and animal welfare issues cannot really be met in "industrialized" breeding conditions because of various contradictions; for instance rabbit is one of the largest consumers of antibiotics among domestic animals (Licois, 1996). To really address animal welfare issues and to begin an era of profitable production, some of these assumptions need to be re-examined. However, virtually every other approach to rabbit management will have a higher labour input. Production adjustments that regulate the reproductive load to each doe's individual carrying capacity, besides improving animal welfare, will provide a longer open period that allows more of the valuable cage-space resource to be filled with working does. In addition to having the benefit of a lower replacement rate (Patton and Ayers, 1992). It was pointed out that a doe in excellent condition with a small litter (<5), may be rebred at 3 to 10 h post partum (Yang *et al*., 1996), while when the litter size is more than seven, it is advisable to choose longer re-mating interval (at least 10 days pp). For longer re-mating intervals (10 to 14 days), does can be mated independent of litter size (Szendro, 1992).

Pseudopregnancy affects reproducing dams far more than is commonly realized. Theau-Climent *et al.* (2000) reviewed the studies carried out by Boiti (1999) and Boiti *et al*. (1996, 1999) and others. The studies showed that about 20% of does become pseudopregnant just after kindling their first litter. Such does ovulate, but fertilization is prevented.

The progesterone levels in young does after kindling may be high (about 9.4 ng/ml) compared with the basal level which is only about one tenth of this value (Theau-Climent *et al*., 2000). Detection of such phenomenon requires availability of a simple test to assess the progesterone level in young does after kindling, otherwise their breeding can be delayed until day 19 post partum or later for their second litter. This may seem to delay the second pregnancy by nine or ten days, but is far less of a delay than that caused by having to rebreed after a failed pregnancy palpation and the possibility of perpetuating the pseudopregnancy condition by unnecessary handling. Pseudopregnancy, as well as, other complications from a previous pregnancy can prevent a doe from being receptive and may result in culling.

RAISING REPLACEMENTS

Replacement stock should have special treatment which could increase their production life and reduce replacement costs.

Does which produce more litters, even one more litter per doe, will increase profitability.

In large rabbit producing countries, meat producers often obtain hybrid replacement stock from the "multiplier" barns and do not save their own young rabbits to raise them as replacement stock, because the hybridization is often a terminal cross. In other rabbit producing countries, the rabbit breeders control their own breeding stock and raise up young rabbits to be herd replacements, both dams and siResearch In most places, replacements are raised the same way as the fryer rabbit production, despite the fact that replacement stock needs special treatment that is not provided for the fryer rabbit output, in terms of kindling interval, kit size, handling, feeding and environment. The rabbit breeder needs to understand that the fryers or broilers are the culls of the herd; they are all the young rabbits that are streamed away from the reproducing part of the herd. Raising a quality replacement doe requires attention to selection and special care of the proposed litter of replacements from their gestation through their nursing, feeding, growing and development stages up to their first mating.

Selection of Dams

Most rabbit herds practice a specific breeding system. This is in order to preserve genetic integrity of the colony through selective mating, or to avoid the negative genetic burden of a known carrier of highly hereditary conditions. The highly hereditary conditions are such as splay leg syndrome that may be expressed in the offspring including a variety of physical disorders such as asymmetric thighs, true shortness and deviations of legs and limited abduction, as an avoidable form of developmental disease that may indeed affect future reproduction (Tena *et al*., 1989, 2002; McNitt *et al*., 1996). The analysis of both the genetic and health standpoint indicates that replacements should come only from good litters of at least 8 kits, born in the nest from dams which have produced at least two or three all-healthy litters. The dam and her sisters should have at least 8 nipples and be good producers, have been sired by a buck with a good record, selected for total litter mass at 3 weeks of age and for adequate 70-day mass (Srensen *et al*., 2001). In case of herds with chronic disease problems, perhaps healthier kits derive from the first litter; in which case it is possible to raise a litter of replacements from a doe's first litter and do her "proving" later. It has been observed also that ideally a NZW doe should have a first litter size of eight to ten kits, in a well-made nest and at least eight to nine of them must be raised up to three weeks of age. Should the breeder fail to follow this criteria, all possibilities indicate that replacements would be then selected from small litters which could result in a selection response trend for lower prolificacy (Zimmermann *et al.*, 1988). However, arguments for and against selecting for large litters and the effects on subsequent productivity were recorded. These arguments indicated that the outcome of selecting from large litters after a while results in larger litters, but often at the expense of litter weight at weaning. As well, the practice of fostering amongst litters to even out litter size may actually be favouring small kits and certainly those saved will be at the expense of larger kits, since there is no change in the milk output of the doe and it is merely shared "more equally" amongst the young (Szendro *et al*., 1989; Szendro,2000).

Heavier birth mass of a doe significantly improves her performance. According to Poigner *et al*. (1999), when a doe was born with a superior mass, her subsequent production litter size at birth was 12.4% larger, litter size at weaning 9.4% higher and litter mass at 21 d was 4.5% greater. Litter size in which the doe was raised (if in the medium range of 6, 8 or 10) did not influence later performance.

The number of teats is perhaps an indirect response to selection for uterine capacity (number born alive). When the number born is three or more than the number of teats, there is not enough time for kits to suckle during the allotted time in which they are randomly able to find a teat. The smaller ones eventually become weak and die of hunger (Moce *et al*., 2000). The number of teats also affects the number of kits that can be fostered to each doe (maximum being number of teats plus two).

Special conditions in pregnancy

Besides selection of a suitable dam and sire to produce a litter of replacement offspring, the dam should not be bred until at least 21 days after a previous kindling to avoid concurrent pregnancy and lactation, since kit weights from large litters or from simultaneous pregnancy / lactation are often low up to or beyond the age of slaughter, beginning from suckling time before consuming any solid feed. Later growth of the rabbit is affected due to any failure to gain, because of competition for nutrients (Rommers *et al*., 1999).

Szendro (2000) reported that the uterine blood flow to the maternal placenta decreases by 18% during lactation compared to an increase of 50% in non-pregnant does as an aspect affecting normal foetal development. It is also considered that at the time of breeding (for replacement stock), the dam should be not less than the appropriate mass for that specific breed. Weight of the doe at conception significantly affects average kit weight at weaning (El-Maghawry *et al*., 1988). The dam should be on full feed during pregnancy.

Considerations at time of kindling

Just before kindling, the dam should be provided with properly cleaned cage, nest, feeder and a disinfected waterer. During this stage the dam should have prepared a good nest consisting of both straw and hair nest. Dams that consistently do not prepare good nests or dams that create problems regarding the nest should be culled. Generally, the doe is allowed free access to the nest, except for several hours after first examination of the neonates. At that time, number and mass of kits and condition of nest, especially the thermal isolation of the kits (by hair and straw), are evaluated.

At birth, a litter of replacement stock should be adjusted to no more than 10 kits, ideally 5 to 9 (Zimmermann *et al*., 1988). Under this criteria, it has been suggested that litter size, besides affecting the expected growth weight, also influences preweaning mortality; for such a reason litter size of 7 to 9 showed the lowest preweaning mortality according to El-Maghawry *et al*. (1988). The kits should be at least 60 g at birth, otherwise the litter is handed over to the fryer production stream. Heavier kits at birth result in better growth rates and less mortality during growth period (Szendro *et al*., 1996; Vasquez *et al*., 1997).

Special conditions in lactation

Parity and remating interval are the main factors that influence progeny's birth mass, litter size and/or birth weight and also affects the growth rate of dams. That may be another reasons for not breeding the dam which produce replacements until at least 21 days after a previous kindling. In this respect, the doe may be placed on a longer rebreeding cycle for the production of replacement stock after she has proven herself in intensive production and is still healthy. A suitable breeding schedule for replacements would be 39-42 days post partum (meaning 5.2 litters per year) and an output of 45 to 50 kits per year. Litter size in the preweaning period does not only affect kit's body growth, but also influences its subsequent reproductive performance (Babile *et al*., 1982; Harkness, 1988). Kit viability is improved with the non-intensive breeding schedule (Patton and Ayers, 1992).

Handling of the kits, especially during the period of 11-20 days of age, influences subsequent behaviours (Anderson *et al*., 1972) and also affects the health status of the replacements, reducing fatty deposits in the aortic wall (Nares *et al*., 1980).

If the herd cannot produce good litters at three weeks of age, a variety of factors needs to be corrected: feed, breed, strain, individual doe differences, physiological state and environment. Nutrient intake of the kits for their first three weeks of life depends entirely on the quality and quantity of the doe's milk and on as few as 21 feedings. Rabbit milk is about 30% dry Matter (DM) and on a DM basis, it contains about 49% protein, 39% fat, 3.2% lactose and 8.5% ash (Maertens, 1993). The doe should be on full feed for the entire lactation. A good all-purpose diet for rabbit is the best suggestion for feeding, i.e. with low starch, moderately high energy, quality digestible protein and about 3% added fat. Dams should have free access to the nest during lactation. Controlled nursing is counter-productive, since it causes lack of growth and prevents the doe's initiation of the kits to eating feed and can increase later mortality from digestive problems (Maertens *et al*., 1988). Young rabbits seems to prefer the diet that their mother ate during pregnancy (Kpodekon *et al*., 1996). However, the practice of diet-switching for various stages of rabbit growth and development ignores the carryover effects of a previous diet (Gidenne *et al*., 1991) on digestibility and the effects on feed acceptance.

Dams should be given a trial period of two or three litters in fryer production before beginning to produce replacement stock, since milk production is higher in later parities (third and higher, up to 7th parity) than in the first or second parities. Milk production level affects litter weight at weaning and during the fattening period.

Rearing conditions

The litter mass should be recorded at 3 weeks of age and should be about five times birth mass or greater. During the period from about 12 days of age to 21 days, the kits begin eating solid feed. It is desirable to feed a small quantity of supplementary alfalfa hay each day during the entire rearing period (3 to 18 weeks of age) for good digestive tract development (Paci *et al*., 2000). Kits should remain with the doe until their 70 days mass is measured. The small amount of milk the doe produces even into the 5th week of lactation helps the immune system of the young.

Young which have not attained 50% of adult mass at 70-days of age are returned to the fryer stream. Any litters remaining with less than three young females are returned to the fryer stream to avoid waste of cage space during the development period. Any losses from enteric conditions during first 70 days of life, returns the entire litter to the fryer stream and the doe to fryer production. The young replacements are maintained by litter group, with up to five animals (for example four does and a buck), since social deprivation can interfere with the development of normal adult sexual behaviour. Dams raised in single cages spent more time nuzzling males and took longer to display lordosis than does raised with their litter mates (Anderson, 1967). The animals are kept in large size cages (at least 90 x 75 cm) equipped with toys, full feed, some alfalfa hay and some (natural) environmental background material such as a small amount of straw provided each day. This cage dimension gives a diagonal travelling distance of about 117 cm which is approximately the smallest dimension suitable for growth of young herd stock, a separate issue from cage density (Mckroskey, 2000). The bucks are segregated at about 16 weeks of age if there is more than one in a litter group, otherwise they may be left with their sisters until the females require their first nest.

Feed restriction

Young does should remain on full feed until 18 weeks of age, at which time they should be 75% of adult weight and may be bred. From age of 18 weeks until day 20 of first pregnancy, they may be on limited feed, about 135 g per day for normal NZW rabbits, during the first 2/3 of pregnancy. Feed restriction should never be done during the last 1/3 of pregnancy, since it reduces litter mass at birth (Rommers *et al*., 1999), foetal dry matter, protein composition (Fortun *et al*., 1994) and hepatic glycogen level which is a major source of neonate energy (Rommers *et al*., 1999). Early loading of a doe by breeding before 18 weeks of age, could be considered abusive and detrimental to health.

Feed considerations:

A doe in full production after two parities may consume about 500 g per day, assuming a standard sized NZW doe. A moderate level of crude fibre, protein, energy, digestible protein to digestible energy ratio (11.5 to 12.5 g DP / MJ DE; Xiccato, 1996) and moderate level of added fat (3%) is essential for reproductive does. The mechanism in rabbits for regulating feed intake involves many factors and interactions, not yet fully evaluated. In some cases rabbits cannot regulate their feed intake according to dietary energy level (Maertens and DeGroote, 1988; Rosell, 1989). The appetite level is thought to be controlled by blood glucose level (Cheeke, 1987), energy content, protein level, rate of passage, aecotrophs production and VFA level absorbed.

CONCLUSIONS

In commercial rabbit production, decreasing an elevated replacement rate inevitably increases economic return. Good husbandry improves the health and productivity of the entire herd and benefits financial viability. Giving the clear benefits of a high quality management and controlling of disease, according to the postulated standards, the current replacement stock practices must upgraded and therefore raised differently than the fryer production.

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