Chapter 5 PATHOLOGY

Introduction

It would be inappropriate here to insert a treatise on rabbit diseases. A disease cannot be described without reference to medical data with which the user of this book is in all likelihood not familiar. In addition, the pathogenic agents of many rabbit diseases are known and in some cases well described, but their presence does not necessarily imply the existence of a disease. Disease is almost always the result of poor husbandry and environment coupled with the onslaught of a pathogenic agent - microbe, virus or parasite.

This chapter therefore starts with a general discussion of the pathology of the rabbit before it goes into more detailed descriptions of the principal diseases.

Appearance and development of diseases

The animal has multiple and interlinking defences for countering attacks from the outside environment. These can be classified arbitrarily and briefly as:

- *non-specific defences,* which can be mobilized very rapidly or even instantly (such as adrenalin discharge), and which bring into play all the major body metabolisms (mobilization of sugars and fats), and all the major functions (blood circulation, breathing, etc.);

- *specific defences,* including immunity, which is how the organism recognizes a hostile foreign body (microbe, parasite, virus, protein) and sometimes, though not always, eliminates it.

The body does not have an infinite capacity for non-specific or specific defence. So the producer's main job is to rear the animal in conditions where it does not have to engage in a permanent struggle for survival.

When it does, the physiologically exhausted animal eventually can no longer defend itself and disease will break out -which disease will depend on the climate, the environment and the type of rabbitry. Not all animal species are equally sensitive to the same kinds of attack. The major known environmental conditions that are unfavourable to rabbit health are described later in this chapter.

The influence of germplasm is unquestionably one element in resistance or vulnerability to disease. In terms of species evolution, however, the rabbit was introduced outside the Mediterranean basin only fairly recently, and new European progenitors have constantly been reintroduced. The concept of "local breed" needs to be viewed with some circumspection.

The environment

The environment is everything that surrounds the animal: its habitat, its congeners, its solid and liquid feed, microbial contamination, temperature, air and noise. The concept of environment can be extended to the farm, village, region and even the country. How far the environment extends is no longer an abstract concept when the number of animals per square metre, hectare or square kilometre grows without a parallel upgrading of hygiene and health standards. An infinity of examples for every species of plant and animal shows that the larger a population grows, the more it becomes imperative that rules of hygiene be respected.

A point that agricultural officials have all too often ignored is that this basic notion is as true at the production-unit level as it is at the village, region or country level. In traditional French rabbitries, for example, pasteurellosis was once a lethal respiratory disease that could decimate the rabbit population of a whole village within a few weeks. Today, the drop in the numbers of these traditional units has led to a marked reduction in the epizootic and lethal properties of this disease.

Myxomatosis decimated the rabbit population in Western Europe in a few months, not only because the virus had been introduced but mainly because the environment as a whole was favourable; the main factor was the overpopulation of wild and domestic rabbits in France at that time. An increase in the number of large rabbitries, combined with expanded trading in France, Spain and Italy, fostered the appearance and simultaneous spread throughout these three countries of three hitherto sporadic diseases: dermatomycosis, staphylococcis and colibacilli O103.

Microbial contamination

Microflora is also a component of the environment. This chapter devotes special attention to microbial contaminations because they are a major, inevitable form of attack in all rabbitries.

Microbial contamination refers to the polluting of air, objects and soil by bacteria, parasites, viruses or fungi. Most often, these microscopic organisms are not intrinsically pathogenic. They become pathogenic when pollution reaches a high, continuous threshold. Ambient microflora is present from the start of production in a unit and inevitably expands as time goes by. One of the breeder's basic tasks is to slow this inevitable increase as much as possible. This is done by respecting the rules of hygiene and by limiting stock to the number of animals that can be maintained and nourished properly. A small, properly run rabbitry is more productive in the long term than a large one that is poorly run. It is also less of a menace to neighbouring rabbitries.

Farmers everywhere know how important and beneficial fallow periods and crop rotation are for the soil they till. One reason these methods are so beneficial is that they reduce local microbial infections specific to each crop. Plant species, like animal species, are each surrounded by their own microbial environment. No matter how capable a breeder is, the day will come when the rabbitry will have to be cleared, thoroughly cleaned and disinfected in order to lower ambient microbial contamination to a safe level.

Rabbitry management

Management (husbandry) is also part of the production-unit environment, but the impact of management on disease is often forgotten. The way breeding and husbandry methods have evolved in different countries shows that any method can have both positive and negative consequences. Age at weaning is undoubtedly the most important variable. Weaning at 28 days does limit or even eliminate the transmission of certain disease agents, such as *Pasteurella* and *Escherichia coli,* but stopping the mother's milk somewhat curtails the passive immunity of young rabbits and unquestionably favours *E. coli.* Weaning much later wears out the dams. Intensified production has led some breeders to opt for a highly accelerated mating calendar (mating following kindling the same day) or for moving the females very often. These choices mean a shorter life for breeding females. Raising rabbits in groups, as is done in the big European producer countries, considerably modifies rabbit pathology.

Breeders need to remind themselves, in deciding how to manage their stock, that the theoretical advantages they see may be accompanied by disease repercussions. As for pathologists, they will need to consider the production methods and not simply the disease agents and symptoms they have identified. Health-care interventions are contingent upon knowledge of these methods.

Conclusion

It would be wrong to think that the following sections will do more than elaborate on the foregoing, for the heart of the matter has already been discussed. The producer's best ally for healthy rabbits is the animals' own capacity to ward off disease. An organism's defence against outside attacks is basically a global, non-specific response which is fundamentally dependent on good hygiene standards in the rabbitry. The rules of hygiene are easier to apply and to respect in small rabbitries with simple equipment that is easy to maintain. Daily preventive cleaning will keep the contamination and pollution levels down and make the rabbitry viable and productive for a longer period. Preventive hygiene is the key to a clean, well-run rabbitry in which the producer can more effectively control any disease which might break out.

Intestinal diseases

This chapter will deal with disease not as a function of the pathogenic agents specific to the rabbit, but as a function of syndromes or combinations of disease manifestations which share common or closely related symptoms and are important in economic terms. Unquestionably, intestinal diseases are most costly to rabbit breeders and the major obstacle to expanded rabbit production. Diarrhoea is a serious economic threat, primarily in young weaned rabbits (four to 10 weeks). It is rare before weaning and can in any case easily be prevented by elementary sanitary and feeding hygiene. It should be noted that diarrhoea appears later in young rabbits than in other young domes tic mammals such as piglets, calves, lambs or even young hares. Among these species diarrhoea strikes in the very first days after birth. The fact that young rabbits do not suffer from neonatal diarrhoea is probably due to their being born hairless and blind, and thus confined for weeks to their nests, sheltered from outside attacks. Diarrhoea is also rare among adult rabbits. It is usually the final consequence of some other ailment.

The first point to make clear is that the rabbit's reaction to disease, whatever the nature of the attack, takes the form of intestinal disturbance, which nearly always expresses itself as diarrhoea. This response can be traced to several features peculiar to the rabbit.

The first has to do wish a rabbit's mental reactions. The rabbit is an excitable animal. Its relatively recent domestication has undoubtedly not yet conditioned it to adjust its alarm reactions (discharge of adrenalin) according to the gravity of the attack.

The second peculiarity is the complexity of the rabbit's intestinal physiology. Caecotrophy is one manifestation of this. The hormone reactions governing the alarm reaction directly affect the nervous system of the intestine, halting or slowing peristalsis, which slows the passage of food through the intestine and halts caecotrophy.

A third feature of the rabbit's post-attack reactions is the alkalinization of the contents of the caecum. The increased pH is linked with the slowed passage of food which modifies the intestinal environment, particularly the flora. *Escherichia coli,* usually few in the healthy rabbit, become dominant. The fact that the soft pellets are no longer ingested also helps to modify the intestinal milieu, particularly the volatile fatty acid balance.

The last peculiar feature of the rabbit is that the appearance of clinical symptoms is delayed after an attack. In animal species that seem to be very excitable (pigs, horses) the symptoms appear most often within a few hours (ulcer, colic, diarrhoea). In the rabbit, an ordinary change of habitat, a scare or a journey have no immediate consequences. Diarrhoea appears only some five to seven days afterwards.

General symptoms of digestive problems

The symptomatology of rabbit enteritis is relatively simple and constant and rarely permits an aetiological diagnosis of the disease. The first signs, scarcely noticed by the breeder, last one to three days, and take the form of a decrease in feed intake (especially solid feed) and in growth. Next, diarrhoea appears, sometimes preceded by complete constipation or production of soft pellets which are not eaten.

Diarrhoea is moderate, consisting of a small quantity of fairly liquid faeces which soil the animal's hindquarters. Death can occur at this stage, sometimes even before the appearance of diarrhoea. Skin dehydration also appears at this time.

Two or three days later the acute phase of the illness starts. It involves an almost total stop in both solid and liquid intake, extensive diarrhoea and high mortality; grinding of the teeth is a symptom of severe intestinal pain. Death follows after several hours of agitated coma with spasmodic twitching. If the animal survives a full day in coma it may recover fully within a few days.

Recovery is in fact remarkably swift. Diarrhoea often gives way to constipation. The pellets are small, hard and malformed. In a rabbit two or three months old, the constipation phase is often the only symptom. Physiologically, however, diarrhoea will have occurred and can be perceived by palpating the abdomen: during the acute phase the breeder can feel that the caecum contents are liquid.

A post-mortem examination shows lesions, usually atypical. During the acute phase the intestinal contents are very liquid, sometimes discoloured. The caecum often fills with gas and contains little food matter.

The intestine is sometimes congested or bruised. The walls of the caecum are most striking, congested and streaked with red, like brush strokes. The colon may be filled with a translucent jelly. There will usually be no fibrin in the abdominal cavity, an indication of the acute stage of this disease.

Causes

Non-specific causes. It has been seen that very different factors can cause outbreaks of diarrhoea. Rabbits seem to react negatively to: transport, especially during the postweaning period; being put in a new hutch or cage; the presence of unusual visitors (people or animals); and sounds not identifiable by the animal and lasting for hours or days, such as work in progress near the rabbitry.

Feeding is unquestionably a prime factor in the occurrence of diarrhoea. Not enough crude fibre, too much protein and meal which has been too finely ground are all unfavourable. Also to be remembered is the fact that the rabbit regulates its intake according to the energy in the feed. Too much energy in the feed can lower the intake too far and vice versa. These are all factors which can favour the onset of intestinal problems. Feed changes are all too often blamed for diarrhoea. Even when feed is the obvious cause, more often the problem is the composition of the feed rather than the change itself. On the other hand, when the animals do not always have good feed available, at least the daily timetable of feeding should be respected. There have been many instances of diarrhoea "epidemics" in rabbitries where a change in timetable was the suspected culprit. This is easily explained by the rabbit's complex intestinal physiology (caecotrophy).

Improper watering is very common in farm rabbitries. It is probably one of the major causes of mucoid enteritis. Rabbits must have clean water available at all times.

It is worth repeating here that the nonspecific causes favouring the appearance of diarrhoea can be defined as anything which forces the animal to spend too much time defending itself against its surroundings.

Specific causes. Theoretically, these include any cause which, alone, allows the disease to manifest itself. In fact, the state of health is almost always the main factor.

Chemical agents. Administration of some antibiotics invariably provokes diarrhoea: ampicillin, lyncomycin and clyndamycin. Antibiotics should always be used very sparingly with rabbits, especially penicillin. It also seems that drinking-water with a high nitrate content causes the chronic diarrhoea observed in some areas.

Mouldy feed (pellets, domestic waste, bread, vegetable peels) can very quickly cause diarrhoea even in a healthy rabbit.

Viruses and bacteria. There has been little work on enteropathogenic rabbit viruses but they are known to exist. It is very likely, however, that as with most other animal species the condition of the animal itself is a decisive factor in the occurrence of viral diarrhoea. The presence of rotaviruses is a good example of the important role of management. These viruses appear in group rearing (all animals in the rabbitry being the same age), with weaning at 35 days (suppression of passive immunity) and after the animals have been grouped (stress) at 42 days.

Much the same is true of bacteria. Salmonella are rarely isolated in sick rabbits but this is not true of *Corynebacteria, Clostridium, Pasteurella* and, especially, *Escherichia coli.* Apart from some *Clostridium* species and a few serotypes of *E. coli,* healthy rabbits carrying these bacteria do not contract the relevant disease. Nevertheless they must be regarded as specific pathogenic agents even if they express their pathogenicity only in a random manner. For example:

- the most pathogenic among them *(Clostridium,* certain serotypes of *E. coli)* can, above a certain pollution threshold in the rabbitry, be the direct cause of diarrhoea and its persistence;

- very often, if not always, they constitute a secondary complication of enteritis which, although not serious at the outset, does become serious and then lethal;

- with both *Clostridium* and *E. coli,* pathogenicity depends in part on toxins which rapidly provoke irreversible and incurable lesions.

Intestinal parasites. All the major parasite families are found in rabbits: trematodes (flukes), cestodes (tapeworms), nematodes (intestinal worms) and protozoa (coccidia). Coccidia are the major specific agents of diarrhoea in the rabbit. In view of their importance the following section is concerned solely with them. The other parasitic diseases will be dealt with as a whole after coccidiosis and bacterial enteritis.

Coccidia and coccidiosis

***Coccidia**.* Coccidia are protozoa, the most primitive phylum of the animal kingdom. They are sporozoa, i.e. parasites with no cilia and no flagella, which reproduce both sexually and asexually. A large number of families are represented. The Eimeriidae family is typified by the independent development of male and female gametes.

Almost all coccidia belong to the genus *Eimeria* - they include four sporocysts containing two sporozoites. Typically they form oocysts, a parasite mechanism for dispersal and defence in an external environment.

The coccidia cycle. Eimeria are monoxenous and have very high host specificity. The rabbit therefore cannot be infested by the coccidia of other animal species, nor can they be infested by rabbit coccidia. *Eimeria* develop in the epithelial cells of the digestive apparatus (intestine, liver). Eggs (oocysts) are found in the intestine and faeces. After maturing (sporulation), the oocysts contain eight "embryos" (sporozoites).

The *Eimeria* cycle includes two distinct phases:

- an internal phase (schizogony + gamogony) in which the parasite multiplies and the oocysts are eliminated in the faeces;

- an external phase (sporogony) during which the oocyst becomes able to infest if it finds favourable conditions of humidity, heat and oxygenation.

The internal part of the cycle begins with ingestion of the sporulated oocyst and the excretion of the sporozoites. The parasite then multiplies. This may entail one, two or more schizogonies (asexual reproduction) according to the species *(E. media,* two schizogonies; *E. irresidua,* three or four schizogonies). It can take place in different parts of the digestive system *(E. stiedai* in the liver; *E. magna* in the small intestine; *E. flavescens* in the caecum). The final schizogony leads to the formation of gametes.

The next step, gamogony (sexual reproduction), ends in the formation of oocysts that are excreted with the faeces; the total duration of the internal phase of the cycle also varies with the species (e.g. E. *stiedai,* 14 days; *E. perforans,* four days).

The external part of the cycle (sporogony) is typified by the extraordinary resistance of the oocysts to the outside environment. Their resistance to chemical agents is particularly striking. In the right conditions of humidity, heat and oxygenation the oocysts become able to infest. They sporulate. Hatching time varies: at 26°C, *E. stiedai* takes three days and *E. perforans* one day.

Coudert (1981) in France and many others have studied this part of the cycle, as the oocyst is the agent to be destroyed. In practice, oocyst resistance is hard to overcome, particularly in disinfecting rabbitries. Chemical disinfection is pointless as oocysts can only be destroyed by heating and drying.

Species. At least 11 coccidia species are rabbit parasites. One infests the liver, the other ten the intestine.

- *Eimeria stiedai,* the liver coccidiosis, causes no economic losses in Europe except at the slaughterhouse. It is relatively easy to eliminate this parasitosis by a few weeks of very strict health and hygiene measures and preventive medicine. A four- to six-week treatment with conventional anticoccidia products (Decox, Pancoxin, formosulfathia-zole) in the feed at preventive doses virtually eliminates the disease. In climates less clement than Europe's and in countries where it is not so easy to get the right medicines, liver coccidiosis can have more serious consequences. As the liver is an organ basic to every process involving homeostasis, chronic liver attacks cannot fail to diminish the animal's resistance capacity.

Intestinal coccidia can be classified in four categories (Table 48):

- *Eimeria coecicola* and *E. exigua* are apathogenic. No clinical sign is detectable even with an inoculum containing several million oocysts.

- *E. perforans is* very slightly pathogenic. Alone, it never causes diarrhoea or mortality. Massive infestations (10^6 oocysts) are needed before there is a slight and very brief decrease in growth.

- *E. irresidua, E. magna, E. media* and *E. piriformis are* pathogenic species that cause diarrhoea and growth retardation of as much as 15 to 20 percent of live weight for infestations with between 0.5 and 1 × 10^5 oocysts. When they occur alone these coccidia are not usually lethal, even in a relatively heavy infestation.

- *E. intestinalis* and *E. flavescens* are the most pathogenic coccidia. They cause diarrhoea and mortality, even at very low dose rates (upwards of 10^3 oocysts).

TABLE 48 Comparative pathogenic strengths of different intestinal coccidia of the rabbit

Pathogenicity	Eimeria	Symptoms
Non-pathogenic or slightly pathogenic	*E. coecicola*	No sign of disease or slight drop in DWG
	E. exigua	

	E. perforans	No diarrhoea
	E. vejdovskyi	
Pathogenic	*E. media*	Drop in DWG
	E. magna	
	E. irresidua	Diarrhoea
	E. piriformis	Little or no mortality
Very pathogenic	*E. intestinalis*	Severe drop in DWG
	E. flavescens	Considerable diarrhoea High mortality

Note: DWG = daily live-weight gain.

Observations

Pathogenic effect has been judged here solely on the basis of retarded growth and mortality. But it must not be forgotten that coccidiosis, like all diseases, can have certain after-effects on the kidneys or liver in particular, which in turn have repercussions on fattening status at slaughter or on the animal's future if it is to be kept as a breeding animal.

Often one disease is also complicated by other diseases. In fact, the above results were obtained with rabbits reared under especially favourable conditions, which means there were practically no bacterial side-infections. It is not known, for example, whether in an unfavourable environment coccidia of the second group (*E. media,* etc.) might not have a more severe impact.

Lesions. There are two kinds of lesions: macroscopic and histological.

- *Macroscopic.* Every coccidium has a preferential place to develop where it causes a reaction of the intestinal epithelium varying in visibility according to the bacterial species. The duodenum and the jejunum are parasitized by

E. perforans, E. media and *E. irresidua.* The latter species is the only one which, at high concentrations, causes macroscopic lesions visible at autopsy. *E. magna, E. vejdovskyi* and *E. intestinalis* multiply in the ileum. *E. intestinalis* causes the most spectacular macroscopic lesions. The ileum becomes bruised and whitens; segmentation appears very clearly, especially in the part nearest the caecum. The appearance of the lesions is the same with high concentrations of *E. magna.* The caecum is the domain of *E. flavescens,* which at medium dose levels produces lesions on the colon. The caecum wall thickens and changes appearance according to whether there is microbial infection or not. It may look whitish in heavy infestations with no complications, but very frequently reddish striations, necrotic plaques or generalized congestion appear. The most constant factor is the emptiness of the caecum. Lesions can be caused in the colon by *E. flavescens* and above all by *E. piriformis,* the only rabbit coccidium capable of causing enterorrhagia in the *Fusus coli* at medium dose levels (30 000 to 50 000 oocysts).

- *Histological.* There are two points to stress here: lesions, both macroscopic and histological, are relatively short-lived. They appear towards the eighth or ninth day and disappear by the 12th or 13th day, despite their sometimes spectacular appearance (*E. intestinalis, E. flavescens* and *E. piriformis).* Histologically, hypertrophy can only be observed in the epithelial cells of the intestine. Cell structure remains intact. Moreover, the number of cells parasitized is extremely low in proportion to the number of cells of the epithelium, but all the cells, whether parasitized or not, look the same. Only a few cell clusters deep in the crypts of Lieberkühn will be destroyed.

***Coccidiosis**.* Coccidia are specific pathogenic agents. When inoculated into rabbits pathogenic coccidia cause the same lesions and the same symptoms (diarrhoea, loss of weight, death) in all the animals tested.

Clinical signs. Most of these are not specific to intestinal coccidiosis. The main symptoms are: diarrhoea, weight loss, low intake of feed and water, contagion and death.

The clinical evolution of an intestinal coccidiosis is illustrated in Figure 22.

Depending on the coccidia species, diarrhoea appears between the fourth and the sixth day after infestation. The peak is from the eighth to the tenth day. It then declines in three or four days. Diarrhoea is the first visible symptom, together with cutaneous dehydration, clinically demonstrated by the persistence of skin folds.

Weight gain and feed intake evolve in a sequence that faithfully follows the evolution of the diarrhoea. For two or three days growth and feed intake are low. Between the seventh and tenth day after infestation there is weight loss, perhaps as much as 20 percent of live weight in two or three days. Recovery is equally rapid. Two weeks after inoculation the animals may resume their initial growth.

Mortality occurs during a relatively short period (three or four days), starting abruptly on the ninth day after infestation.

The intensity of these general symptoms naturally varies according to the *Eimeria* species involved (see above), the degree of infestation and the animal's general condition. Identical effects can be obtained by using different dose levels of different species of *Eimeria.*

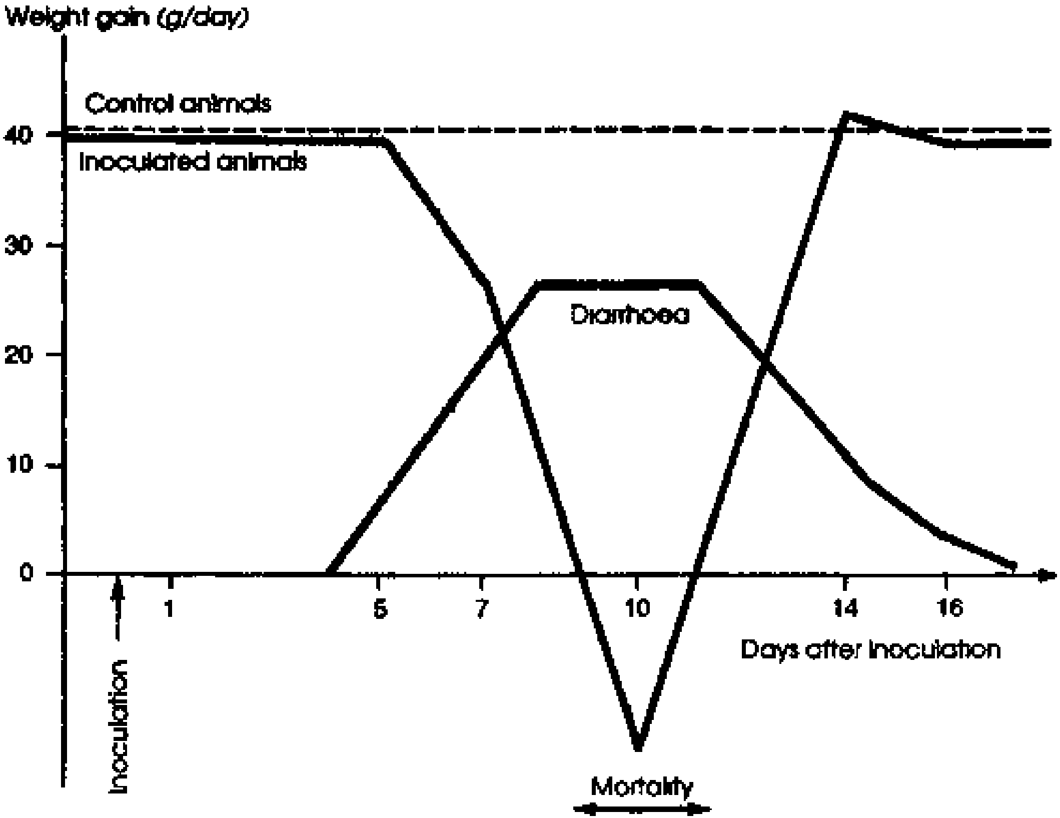
Few data are available on simultaneous infestations, but there appears to be no synergistic action among the various species except with *E*. *piriformis,* which seems to augment considerably the pathogenicity of other species. This is rather easily explained by its locus of implantation and the fundamental role of the colon (see physio-pathology, below).

It is common for bacterial flora to develop at the same time as coccidiosis, complicating and aggravating the symptoms of the disease.

If there has been no contact with coccidia (non-immune rabbits), then age is not a major factor in susceptibility in rabbits. The disease is briefer in animals 10 to 11 weeks old and diarrhoea less severe, but weight loss and mortality are often more pronounced than in younger rabbits. However, the early contact does confer relative immunity.

Physiopathology of diarrhoea of coccidian origin. The main symptom of intestinal disease in young rabbits is diarrhoea. Rabbit enteritis following cocciodiosis has been studied with reference to calves and human infants, in whom episodes of diarrhoea are essentially linked with hydromineral perturbations. In calves and infants diarrhoea seems to be dominated by three main phenomena. There is, of course, considerable loss of faecal matter. The usual impact on the metabolism is extracellular dehydration and metabolic acidosis. Rabbits suffering from diarrhoea, like calves and infants, certainly have more watery faeces, but sick animals produce a smaller quantity of faeces than healthy ones. Calves and infants urinate little or not at all with diarrhoea and there is haemoconcentration associated with extracellular dehydration. In young rabbits, diuresis is not altered during diarrhoea and there is haemodilution. The distribution of water in the organism is unmodified except that the skin is heavily dehydrated. Blood pH is normal. The most marked modification of the blood plasma is severe hypokalemia.

FIGURE 22 The clinical evolution of coccidiosis



The pathogenesis of diarrhoea in the young rabbit thus appears to differ from the more conventional diarrhoea of the calf or infant, but the prime mover at the intestinal level seems to be common to all. In diarrhoea of calves due to *E. coli,* for example, the small intestine secretes water and minerals, especially sodium, which will be lost by the animals.

In the young rabbit there is also a lack of reabsorption - indeed an actual secretion -of sodium and water in the loci where the parasites multiply. Unlike calves, however, rabbits can compensate for these disturbances in the distal colon and, most important, they can initiate an Na-K exchange which limits sodium losses to a minimum. Potassium losses are replaced from body reserves. These parameters evolve at the same time as the symptoms described earlier. Peak intensity of symptoms occurs at about the tenth day after infestation. Certain elements are generally described as constants in rabbit enteritis: lengthening of the retention time of the ingesta in the intestine, high levels of colibacilli and intestinal pH tending towards basicity.

This suggests that the basic phenomena of the pathogenesis of diarrhoea are independent of the aetiology (infectious agents or non-specific causes) and that the diarrhoea syndrome is a complex process. It may lead to a single response but several elements are involved - digestion, flora, motility, absorption and secretion.

It could, likewise, be tempting to attribute the sometimes spectacular lesions to the pathogenicity of the coccidia. But this would overlook the fact that these modifications in hydromineral metabolism and pH are delayed manifestations of an attack that took place days before.

Coccidiosis and field conditions. All production units are parasitized, usually by several species of coccidia. Investigations show that the least pathogenic species are the most numerous *(Eimeria perforans, E. media). E. magna* is also very common and of ten found in great numbers. *E. intestinalis, E. flavescens* and *E. Irresidua* are less common. This is a good thing, because their mere presence is a real menace to the rabbitry. E. *piriformis* is rare in Europe and *E. intestinalis* has not been identified in Benin.

It must not be forgotten that a single pellet from a healthy rabbit raised in a sound, clean rabbitry usually contains enough coccidia to cause diarrhoea if the same number were inoculated into the animal. Yet not all rabbits contract clinical coccidiosis. It almost always depends on conditions in the rabbitry. If conditions are good only a few animals will die of diarrhoea. If conditions are bad there will be a chronic mortality rate of 10 to 15 percent. Indeed, this is the usual situation.

Whether the environment is good or bad, any stress can set off coccidiosis, whatever the animal's age. It is curious to note that diarrhoea strikes not only young, newly weaned rabbits, but also older animals which have been in contact with the parasites for several weeks. Naturally acquired specific immunity is always very weak.

The outbreak of coccidiosis, the progress of which is summarized in Figure 23, can therefore be attributed mostly to stress.

Non-specific stress occurring singly cannot cause diarrhoea in a rabbitry where sanitary standards and physiological comfort are good. In such an environment the animal is able to marshal fully its nonspecific defence potential. On the other hand, a simple change of feed in a rabbitry with a poor environment is enough to set off diarrhoea. The mere fact of raising five or six rabbits together in a cage one-third of a square metre in a room with 100 or 1 000 other cages acts as a sort of sounding board to amplify all these phenomena.

Finally, non-specific factors cannot be discussed without mentioning their intensity - five minutes of transport does not constitute the same amount of stress as does four hours. These upsets are the root cause of outbreaks and it is only later, in most cases, that specific disease agents intervene (viruses, bacteria, coccidia). Each agent, merely by its permanent presence at low or average level, can also help undermine the rabbit's defence mechanisms without there necessarily being any permanent clinical disease.

The same is true of the other specific chronic diseases such as respiratory ailments and myxomatosis which by the very process of sapping the organism's defence capacities will become the indirect agents of outbreaks of coccidiosis and diarrhoea. Cases of primary coccidiosis are therefore probably rare. They can nevertheless occur, in particular when animals which are carriers of pathogenic species are introduced to the rabbitry.

Diagnosis. Coccidiosis is often extremely difficult to diagnose. It can only be done in the laboratory, by counting coccidia per gram of excrement and examining the viscera. Counts must be made on several animals for several days running to diagnose coccidiosis properly. The specific coccidia species and their pathogenic potential also need to be identified.

FIGURE 23 Development of coccidiosis

For coproscopic investigations, examination of excreta several days old taken from under a cage where there are several animals is preferable to and far more reliable than a caecum contents examination. At any given moment (death or slaughter of the animal) there may be:

- no trace of coccidia and coccidiosis: this is the not uncommon case in animals that die before the completion of the coccidial cycle;

- few coccidia and little coccidiosis: as above, with mortality occurring a little later. This happens mainly with very pathogenic coccidia which kill rapidly (*E. intestinalis, E. flavescens*) even at low concentrations;

- many coccidia and no clinical coccidiosis in the case of infestations with not very pathogenic coccidia (*E. coecicola, E. perforans, E. media).* The multiplication of the parasite will none the less be a negative factor.

Despite these difficulties it can be stated categorically that the presence of *E. intestinalis, E. flavescens* and even *E. irresidua* or *E. piriformis* is a serious circumstance and, for the first two, a definite menace. A post-mortem examination is often disappointing. The typical coccidiosis lesions appear only with massive infestations and persist for only two or three days. The presence of whitish spots on the intestine is an indication, but not a proof, of coccidiosis. In any case, it is recommended that an autopsy be carried out on all dead animals. A combination of observed factors, even if observed hastily, is far preferable to an isolated finding.

Liver coccidiosis, on the contrary, is very easy to diagnose. The presence of small whitish-yellow patches or small nodules on the surface or inside the liver is typical of this disease. But only massive coccidiosis, which sometimes provokes spectacular liver hypertrophy and considerable weight loss, can account for mortality.

Prognosis. A coccidiosis prognosis will not be of much use unless the expert also diagnoses why there has been an outbreak. All rabbits are coccidia carriers so it cannot be attributed to the parasites alone (they were already present). Conditions in the rabbitry and the animals' resistance being such as to produce a multiplication of *Eimeria,* the environment must also be examined and treated. This is why the prognosis is often quite bleak.

Control. Treatment is often disappointing and always expensive. There are basically two reasons for this:

- medical treatment is not really appropriate unless the cause of the disease is known. In the rabbit, the disease most often begins through a combination of several non-specific factors. The environment thus needs to be dealt with first;

- anticoccidiosis treatment is feasible for animals that have been infected for only a few days (five or six), but it is not effective otherwise. Even after successful treatment it should be realized that mortality and diarrhoea will continue in the rabbitry for a few more days. The most disappointing thing is that an improvement lasting one or two weeks is often followed by a relapse. It must be understood that a few days of diarrhoea in a rabbitry breeds thousands of millions of coccidia, only a few hundred of the most pathogenic of which are enough to kill an individual rabbit.

Sulpha drug treatment. The most common drugs are nitrofurans and sulpha drugs. The former have been used non-stop for nearly 30 years in feed. This may be one reason why present-day coccidia control is so ineffective. Nonetheless, the bacterio-static activity of these drugs probably favours recovery or avoids problems. Bifuran (50 percent furazolidane, 50 percent furoxone) at rates of 200 mg/kg of feed is now used only as a preventive measure.

Sulpha drugs are most effective in treatment, not in prevention. Sulfadimethoxine is the most effective sulpha drug and the one best tolerated by nursing or pregnant does:

- curative dose: 0.5 to 0.7 g/litre drinking-water;
- preventive dose: 0.25 g/litre drinking-water.

The bacteriostatic activity of this drug, especially on pasteurellosis, makes it one of the best rabbit medicines. It should not be overused.

Sulfaquinoxaline is commonly used, but at higher doses:

- curative dose: 1 g/litre drinking-water;
- preventive dose: 0.50 g/litre drinking-water.

Sulfadimerazine, at 2 g/litre, is less effective.

These sulpha drugs can be boosted by antifolics, such as pyrimethamine or diaveridine, which allows the dose to be reduced considerably, but this increases their toxicity, especially for pregnant does. The use of sulpha drugs for pregnant does must be systematically avoided.

Formosulfathiazole is another excellent coccidiostatic drug at rates of 0.5 to 0.8 g/kg of feed as a curative measure, or 0.3 to 0.5 g/kg as a preventive measure. Unfortunately it is not water-soluble.

Curative treatments should always be applied to all growing animals for four or five consecutive days followed by a therapeutic rest.

Treatment is then resumed for a further four or five days. If the medicine is given in the drinking-water care must be taken that the water is constantly clear. Where animals are fed watery forage such as roots and greens, these should be replaced by dry feeds or the animals will not drink enough water. Drug concentrations as generally indicated correspond roughly to a water intake of 100 to 150 g water per kg of live weight. When water intake exceeds this normal quantity (nursing does, very hot weather) the drug should be further diluted. Stepping up the concentration is not really possible - the rabbit would then probably refuse to drink the water.

Treatment with antibiotics. Antibiotics do not cure coccidiosis. They may, however, be used in cases of persistent diarrhoea or to prevent secondary bacterial complications. The most common antibiotics used for rabbits are neomycin (0.1 to 0.4 kg/litre of drinking-water), colimycin (3 to 4.10^5 IU/litre) and the tetracycline group (0.2 to 0.3 g/litre). Once treatment with antibiotics is started it must be continued for three or four days at steady doses if it is to have any chance of being effective.

Antibiotics must be used cautiously in treating rabbits. Some that basically act on gram-positive flora are toxic to rabbits (ampicillin, lyncomycin, clyndamycin), while others should not be administered orally (chloramphenicol, penicillin, erythromycin, tylosin). With the possible exception of neomycin and the tetracyclines, antibiotics always entail the risk of digestive troubles.

In treating undiagnosed diarrhoea the proper treatment of coccidia alone is often enough to reverse the situation. Many French and other authors stress the importance of intestinal coccidiosis as a factor in the outbreak of enteritis and the benefit of treating coccidia. It should be remembered that giving medicine is not in itself sufficient treatment.

Prevention. Non-specific attacks and coccidiosis are the basic causes of diarrhoea. Diarrhoea prevention therefore consists of controlling these two factors. Good hygiene is the proper way to prevent the first. Preventive medicine should be added to combat coccidiosis.

There are two kinds of preventive medicine: vaccination and chemopreventive treatment. There is no anticoccidiosis vaccine (as of 1996). Active research is ongoing and hopefully short-cycle attenuated strains may soon be seen (early strains). Doses of sulpha drugs (see preceding pages) given to the young rabbits at weaning for eight to ten days are a good preventive measure in problem rabbitries.

Anticoccidial drugs administered as a preventive measure in balanced pelleted feeds are without doubt the most popular control method. A certain number of products can be used for rabbits (Figure 20). Robenidine has been used as a food additive in Europe since 1982 (66 mg/kg) and is very effective and well tolerated by rabbits. But ten years of use in the region have produced chemoresistance (*E. media* and *E. magna).* Others are effective (Lerbek) or highly effective (Salinomycin, Diclazuril, Toltrazuril-hydrosoluble), but had not been used for rabbits as of 1993. Anticoccidial products of the ionophore family used in poultry husbandry are usually very toxic to rabbits: Narasin, Monensin, Maduramycin. Some are well tolerated (Salinomycin 20 ppm; Lasalocid 50 ppm), but overdosage must be avoided. Anticoccidial products much in use in poultry husbandry, such as Amprolium and Coyden (methylchlorpindol), have little, if any, effect on rabbits. Coudert (1981) has made an exhaustive bibliographic review of these products. The disadvantage of such drugs is that they are not water-soluble, which means they can only be administered in balanced pelleted feeds. Antibiotics added to feed in constant low doses are strongly warned against as ineffective and dangerous.

Preventive hygiene is the keystone of coccidiosis control and successful rabbit production. It is far more important than any other anticoccidiosis measures and for this reason the last section of this chapter deals solely with preventive hygiene.

Acquired immunity to coccidia is species-specific. Coccidia cannot develop in young rabbits before 21 to 25 days, i.e. while lactation is the principal source of nourishment. The presence of coccidia before the age of 28 days is a sign of insufficient milk or poor hygiene. After weaning, in the presence of contamination, immunity is acquired in 10 to 12 days and lasts to adulthood. Acquired resistance is weakened, however, by the immunodepressive effect of major stress.

Bacterial enteritis

Apart from coccidiosis there are two other classic types of rabbit diarrhoea. Renault (1975) has published a detailed description of the mechanism of these diseases.

Mucoid enteritis. A special kind of diarrhoea sometimes affects growing rabbits and nursing does: very soft pellets are mixed with a translucent, gelatinous substance called mucus. Autopsy shows the colon and rectum filled with considerable amounts of this mucus, which somewhat resembles egg white. All sorts of hypotheses have been put forward to explain this type of diarrhoea. It is now universally considered a particular expression of enteritis which can have many varied causes: bacterial (*E. coli,* etc.) or nutritional (not enough water and/or not enough roughage).

Enterotoxaemia, colibacillosis, typhlitis.

These various names, like mucoid enteritis, refer in fact to types of enteritis which may have different causes but are very similar clinically and necroscopically. The diseases often develop rapidly (three or four days). Death can intervene before diarrhoea appears. When developing enzootically in a rabbitry there are phases of mucoid diarrhoea or constipation.

The autopsy shows lesions not dissimilar to those described for coccidiosis. There is more gas in the caecum, which is frequently mottled with red striations. The liver and kidneys sometimes look abnormal (crumbly liver, discoloured kidneys). The bacteria most often blamed are *Clostridium* spp. and *Escherichia coli.*

Clostridia *(C. perfringens, C. welchii, C. septicum)* are hardly ever isolated in growing rabbits after weaning. Perhaps this is partly because these are anaerobic germs which require a battery of special techniques for isolation and identification. *Clostridium spiroforme* has often been described in rabbits in recent years. This type of enteritis is common, mostly in well-fed animals (perhaps due to excess protein?). Both young and breeding animals may be affected. The diarrhoea is often very liquid and characteristically quick to putrefy. The corpses are blown up and the autopsy reveals greenish viscera. Treatment aimed specifically at anaerobic bacteria can be effective (Dimetridazol, Tetracycline + Imidazol, etc.).

E. *coli,* on the other hand, occur systematically in very large numbers in rabbits with diarrhoea or even with coccidiosis. It should be remembered that a healthy rabbit, unlike all other animal species, hosts very few colibacilla (10^2 to 10^3/g faeces). Some authors have isolated nearly 200 different strains in sick rabbits. Fortunately, not all are pathogenic and the number of serotypes (strains) involved is relatively small. Serotype O103 is virtually the only one considered specifically pathogenic in France. Licois (1992) and Peeters (1993) have done wrap-up studies.

The enteropathogenicity of these strains comes from toxins they secrete. However, diarrhoea has rarely been produced experimentally using these enteropathogenic strains alone (O103). For these *E. coli* to cause diarrhoea the animal has to be under some other stress at the same time (unbalanced feeding, coccidia, thermal shock, etc.).

Strictly speaking, colibacillosis is mainly a postweaning disease. Diarrhoea in unweaned rabbits is usually a consequence of poor maternal health. Since the young drink only milk, to treat neonatal diarrhoea one treats the mother. There has to be enough antibiotic in the milk. Because antibiotics are held back and rapidly broken down by the intestinal wall, the drug administered in the dam's feed must be supplemented by parenteral administration. Rabbits are less susceptible to diarrhoea after seven to eight weeks. Broad-spectrum antibiotics (colistin, flumequin) plus general hygiene can redress the situation where there is no other major primary cause, e.g. feed, population density or maternal health.

Some antibiotics are very toxic to rabbits, particularly penicillins, ampicillins, amoxillins and other betalactamins, virginiamycin, lyncomydn and oxolinic add (toxic embryo).

***Conclusion**.* While the clinical and necroscopic appearance of these diarrhoeas of non-parasitic origin differs somewhat from that of coccidiosis, the conditions governing their occurrence are the same. First and foremost the field conditions must lend themselves to the spread of the infectious agent (*E. coli* or coccidia). Some factors perhaps more specifically favouring this type of diarrhoea are excess protein in the diet (over 18 percent) combined with insufficient roughage (under 10 percent indigestible crude fibre). Such enterotoxaemia, often associated with coccidiosis, is frequently reported from farm rabbitries where the rabbits are fed fresh-cut forage which is strewn on the ground.

Curative treatment is always too late, given the acute nature of this kind of enteritis. Antibiotics and sulpha drugs will prevent the spread of the disease and very often it is enough to replace the feed (pellets or green forage) by some good dry hay to cut losses. But if nothing is changed in the general conditions of the rabbitry, the same problems will soon recur. Chronic pasteurellosis, particularly during fattening, is also a direct or indirect cause of diarrhoea and mortality in rabbits.

Other gastrointestinal parasites

Glancing through a book on parasitology the reader soon discovers that several dozen different sorts of parasite can be found in the rabbit's digestive tract. They will not all be dealt with here as most are either very rare or only pathogenic under exceptional circumstances, or else little known or unknown in domestic rabbits. But in the farm rabbitry context, especially in the tropics, it is useful to have a basic grasp of the biological conditions that favour the development of such parasites.

Only two intestinal parasitic diseases are found in rational rabbit production in Europe: coccidiosis and oxyurosis. Wild rabbits living in the same regions, however, have many other parasites. The main reason for this has to do with the various parasite cycles. Many are heteroxenous (multihost): to multiply and develop they must live successively on several hosts. For example, the little liver fluke shifts from mammal to snail to ant to mammal. Others are monoxenous (single host) but the larval or adult form develops only in the outside environment under certain conditions (wet grassland, stagnant water, etc.). This explains why rational production, by breaking the life cycle of these parasites, has eliminated the parasitic diseases they cause.

Intestinal parasites found in farm rabbitries.

Cysticercosis (tapeworm). This common parasite produces fine, white streaks on the liver and translucent cysts, alone or in bunches, on the peritoneum and viscera. The cysts are produced by the larvae of dog and cat tapeworms. Rabbits are contaminated by eating feed that has been in contact with excrement. The terminal hosts (dog, cat, fox) become carriers by eating rabbit viscera. Symptoms are few - sometimes diarrhoea -except with heavy infestations (not uncommon) when growth rate slows. There is no curative treatment. The other domestic animals have to be treated. Tapeworm larvae of other species of animals (pig, rat, etc.) can also infest rabbits. It is worth mentioning here that the larvae of some dog and cat tapeworms can infest not only rabbits but people as well (echinococcosis, coenurosis). The lesions are cyst clusters forming translucent "tumours" on the viscera or in the brain.

Taeniasis (tapeworm). Half a dozen tapeworm varieties can infest rabbits which become contaminated by eating mites in wet grass. Clinical symptoms are slight: mild diarrhoea, sometimes weight loss, very rarely mortality from intestinal perforation. A necropsy reveals flat worms, a few millimetres wide, varying in length by species from 1 cm to 1 m.

Tapeworms are seldom found in domestic rabbits. Treatments applicable to other animal species may be used.

Fasciola spp. and *Dicrocoelium* spp. (trematodes). Liver fluke *(Fasciola hepatica)* and little fluke *(Dicrocoelium lanceolatum) are also* very rare in rabbits. The conditions of infestation are the same as for ruminants. The intermediate hosts are certain snails found in grass from marshy areas *(Fasciola* spp.) or other types of snails and ants *(Dicrocoelium* spp.). Usually the only symptom is slowed growth. Treatment is pointless.

Trichostrongylus (nematodes). These are also small round worms (called round-worms), measuring 4 to 16 mm in length. The *Graphidium* (stomach worm) is rare in Europe but *Trichostrongylus is* very common in farm rabbitries. Rabbits become infested by eating green forage contaminated by larvae. The intrinsic pathogenic strength of these parasites is relatively weak, but they do greatly aggravate other rabbit ailments, particularly diarrhoea. Massive infestations can cause extreme inflammation of various parts of the intestinal tract (stomach, small intestine, caecum). The conventional anthelmintics (thiabendazole, phenothiazine, tetramisole) can be used for rabbits. It is recommended that regular treatments be applied every month or two in contaminated farm rabbitries.

Two other small roundworms are frequently found in rabbit caeca and colons: *Passalurus* (oxyuris) and *Trichuris.* These do not appear to be pathogenic except with massive infestations.

Strongyloïdes (nematodes). These are small roundworms, a few millimetres long, that are able to migrate throughout all organs and reach the intestine. The aetiology and epizootiology are identical to those in ruminants and pigs. Some massive infestations have been described in rabbits living in dark, damp, poorly kept hutches.

Preventive hygiene and intestinal parasites.

Intestinal parasitism is very common in wild rabbits. It is frequent and not of great economic importance in farm-bred domestic rabbits if overall sanitary and health conditions are satisfactory. In poorly kept hutches, or where infestation is massive, these parasites enhance all other ailments, both intestinal and other, making them acute, enzootic and lethal.

Rational rabbit production has done away with all these intestinal worms. Control is easy; it is only necessary to break the parasite's life cycle. Essentially this means taking the following measures regarding forage:

- it should not be gathered in areas where there are large numbers of dogs, cats or wild rabbits;

- it should be stored out of reach of these animals;

- it should be gathered at midday when the dew is gone (avoiding marshy areas) and not be cut too near the ground, because many of these parasites avoid dry surroundings and strong light;

- it should be sun-dried before it is given to rabbits - drying kills most of the worms and their larvae;

- it should be distributed on feed racks where animals are unable to soil it with their faeces or urine.

Parasitism can be considerably cut back by frequent changing of the straw litter, which should always be dry. Late slaughter of fattening rabbits (three months or more) is a negative factor, as some parasites (oxyuris) have a rather long life cycle. This is interrupted by earlier slaughter. Regular treatment can also include broad-spectrum anthelmintics or copper sulphate-based preparations in drinking-water (1 percent) for one or two days.

Respiratory diseases

Respiratory ailments are common among domestic rabbits. In rational production they essentially strike breeding adults. In a farm rabbitry young rabbits can also be affected. Where such ailments are endemic, losses are especially to be feared among the females, in which the disease becomes chronic, leading to production stoppages and mortality among the nursing young. Respiratory diseases usually remain endemic, but abrupt epidemics, which can decimate the stock in a few weeks, sometimes break out in farm rabbitries.

Clinical features

The first symptoms are a clear, fluid nasal discharge and frequent sneezing. The rabbit often rubs its nose with its forepaws, the fur of which becomes matted and dirty. This is the first stage, or common coryza, which affects the upper respiratory tract.

Later the discharge turns yellowish, thick and purulent. Sneezing is less frequent but coughing may begin. Purulent coryza can remain stationary or develop into pneumonia, either spontaneously or from other specific or non-specific causes (enteritis, lactation, malnutrition, etc.). With pneumonia, coryza, sneezing, even coughing and snuffling may disappear. The only symptoms will be slower respiratory movements, clearly visible in the nostrils, and difficulty in breathing in. In young rabbits, growth slows or stops. Complications are frequent: diarrhoea, ophthalmia, sinusitis, torticollis (wryneck) and abscesses. Females can die suddenly during lactation or gestation.

At autopsy, coryza is manifested by the presence of pus in the nasal cavities and atrophy of the mucous membranes. The lungs may be congested and parts may have a liver-like appearance. Very often there are lung abscesses with abundant yellowish-white caseous pus filling most of the chest cavity.

Causes

As with diarrhoea, respiratory infections are due to an association of non-specific contributing causes with infectious agents.

Many of the non-specific attacks mentioned in the previous sections are decisive for the development of respiratory ailments. Control of chronic enteritis in fattening units, in particular, will reduce the incidence of coryza. Other contributing causes are directly linked with rabbit respiratory physiology. The lungs are protected by the rabbit's very developed, very complex nasal cavities. These cavities are covered by the pituitary membrane which acts as a filter to stop dust and airborne microbes. It is therefore essential to protect this mucous membrane and keep it intact. The pituitary membrane is particularly sensitive, which may explain many of the following observations:

- abrupt cooling of the air can be the sole cause of common coryza, which may clear up spontaneously and quickly in a healthy environment;

- dust (crumbly granulated feed, pollen, dust in the air from dry sweeping or a nearby dirt road) can cause common coryza through the reflex action of the pituitary membrane, but may also clear up quickly;

- air flow, humidity and temperature are three very closely linked environmental factors that are instrumental in triggering respiratory ailments. At lower temperatures the air must be correspondingly drier and move more slowly. Rabbits seem to be very sensitive to draughts. Air flow should not exceed 0.30 m/second unless the humidity is more than 75 percent. Ventilation errors in closed buildings are the chief cause of chronic pneumonia;

- ammonia and gases forming from decomposing, urine-soaked straw litters may quickly break down the pituitary membrane and gain direct access to the lungs.

***Infectious agents**.* Three constants of disease agents are the randomness of their pathogenic strength, their numbers and the fact that they are interchangeable. In other words, only some alteration in the mucous membranes of the upper respiratory tract will allow the germs present to develop to their specific pathogenic strength.

Bacteria. Pasteurellosis is the disease most often cited, because rodents and lagomorphs are particularly susceptible to this germ. Pasteurellosis may take many forms in the rabbit: abscesses, mastitis, diarrhoea, metritis, wryneck or septicaemia. The rabbitry can easily become thoroughly infested, to the point where pasteurellosis can become endemic. Some pasteurella strains are more pathogenic than others. Pathogenicity can be acquired during the endemic stage, provoking an epizootic outbreak in the rabbitry or even in the entire region (Rideau *et al.,* 1992). While pasteurella is the worst and most common of the germs isolated from the respiratory apparatus of a sick rabbit, there are others: e.g. klebsiella, staphylococci, streptococci, bordetella, *E. coli,* salmonella and listeria. These are usually secondary infections or associations such as streptococci and bordetella.

All production units are contaminated with pasteurella and, while there may not be respiratory pasteurellosis, the constant threat is there, and varies with the pathogenic strength of the strain.

Viruses. Apart from myxomatosis, which now seems more and more likely to cause pneumonia, no respiratory virus has been described in the literature. Viruses certainly do exist, however, and in rabbits as in other animal species, the problem is the bacterial complications which follow viral infections.

Parasites. There are several species which can develop in the lungs *(Protostrongylus* spp., linguatulids, etc.). They are relatively uncommon in domestic rabbits because, as with intestinal worms, an intermediate host such as a snail or dog is required. Only a laboratory analysis can reveal the presence of respiratory parasites.

Epidemiological and physiopathological elements

Pasteurella are basically transmitted through direct contact such as mother to progeny, male to female, or via a vehicle such as the drinker, the trough or the breeder's hands. These bacteria cannot live very long outside the body, making sanitary isolation effective.

Airborne transmission is infrequent and only effective if the air is full of dust or water particles.

In a healthy production unit, young rabbits are unlikely to be contaminated before the age of 21 to 25 days. Most adults are silent carriers. The sites most commonly colonized are the sinuses, vagina and middle ear. Autopsies show that more than 60 percent of female rabbits have asymptomatic pasteurella-associated otitis of the middle ear. Pasteurella are carried into the inner and middle ear by the lymphatic system in a two-way direction.

Other pasteurella affections are frequent: cutaneous abscess, mastitis, vaginitis and metritis; the last two more frequent in units where artificial insemination is practised with unsterilized implements. All these external suppurative forms are incurable and affected animals must be culled immediately.

Respiratory disease control

Chemotherapy. Tetracyclines are pneumotropic antibiotics well tolerated by rabbits. Chloramphenicol and sulfadimethoxine are also often effective. Dosages vary according to the preparation but treatment should always be for three to four days. The medicine is best injected intramuscularly. Whenever a bacterium is isolated in the laboratory it is strongly recommended that an antibiogram be made immediately. Although antibioresistance is rare in rabbit pasteurellosis, resistance to streptomycin, spiramycin and the sulphonamides is reported. Systematic preventive antibiotic treatments are both useless and dangerous.

Vaccination. The numerous vaccines on the market are of very uneven effectiveness. Most of them are pasteurella-based and sometimes bordetella-based. It is difficult to immunize rabbits against these two germs, whatever the quality of the vaccine. The main point is that bacteria are only exceptionally the direct cause of the disease, so that even if the rabbit is protected against pasteurella, it can still catch pneumonia from streptococci or staphylococci.

Given the large number of pasteurella strains and their variable pathogenicity, autovaccines are always preferable. Furthermore, to be at all effective, vaccination must be performed on healthy animals just after weaning and repeated one month later. Action is generally taken during the course of the disease only. Vaccination and chemotherapy are merely temporary measures to back up preventive hygiene.

Preventive hygiene. Preventive hygiene is the *sine qua non* of successful respiratory disease control, even more so than for digestive disorders. Where pasteurellosis is endemic in a nursery, the breeder needs to know that a long battle lies ahead for which the following strategy is proposed. Where possible, the first action, before administering antibiotic treatment, is to remove two or three sick rabbits to identify the germ, make an autobiogram and perhaps prepare an autovaccine. Successful control depends on culling sick animals, which the breeder will need to be able to replace. Pasteurellosis control should be preceded by the preparation of new breeding females from the youngest (newly weaned) animals which have been isolated, treated and perhaps even vaccinated.

The first stage of pasteurellosis control is the elimination of all clinically diseased animals: i.e. those with signs of suppurating coryza, sniffling, breathing problems, abscesses, mastitis, vaginal discharge, etc. The second stage is to analyse the nursery environment: i.e. air flow, ammonia, humidity, temperature, dust content. No specific control is possible unless the environmental problems are identified and solved. The third stage (and hopefully not the first) is antibiotic treatment with tetracyclin, chloramphenicol, etc.; it is particularly effective if administered for long enough and by parenteral injection.

The bacteriological clean-out of the unit should be supplemented by extra-rigorous cleaning of the floors, walls and all equipment and implements.

Culling of the sick is to be followed by the removal of healthy carriers such as old females, non-productive females, females that refuse mating or that abort, females with coryza in the late stages of pregnancy, etc. Male rabbits are formidable healthy carriers.

New females should not be brought in until the situation has improved, i.e. several weeks after the start of the operations. This must not signal a slackening of vigilance in either maintenance of a sound environment or good hygiene. Culling of the breeding animals retained should continue.

Other disorders of the rabbit

There are many rabbit diseases other than digestive and respiratory ailments. Most have disappeared from intensive rabbit production without the reason always being known. Others are still found in farm rabbitries but are rarely of economic importance. The following is a brief review of diseases that are not uncommon.

Myxomatosis

This is a viral disease (Sanarelli virus) which decimated rabbits in Europe for more than 20 years after being introduced into France in 1952. The Sanarelli virus develops in certain American rabbits, *Sylvilagus* (cottontails), without causing the disease, thus making them dangerous carriers.

Myxomatosis is extremely contagious and can be transmitted in many ways. Biting or stinging insects such as mosquitoes and fleas are the main vectors because of the rapidity with which they can inoculate animals and the distances they are able to fly. Spread by animal-to-animal contact or from contaminated equipment is also common. It now appears certain that pulmonary contamination is possible in confined rearing. This virus is very resistant to weather and physical changes (cold, dryness, heat) and disinfectants. Formol, however, is very effective and is recommended for disinfecting equipment.

Pasteurellosis eradication plan: order of operations

1. Cull live animals for laboratory examination (antibiogram and autovaccine).

2. Prepare a stock of future breeders to replace animals culled, isolate them, treat them and vaccinate them if possible.

3. Cull sick females, including those with suppurating coryza, sniffling, breathing problems, abscesses, etc.

4. Check and modify the environment (air flow, ammonia).

5. Administer appropriate antibiotic treatment to the remaining stock.

6. Wash and disinfect cages, hoppers, drinkers, floors and walls.

7. Continue to eliminate healthy carriers for several weeks or even several months, i.e. cull females which are not productive, refuse the

male, do not get pregnant or abort.

8. When the situation improves, renew stock with young vaccinated females and continue the accelerated renewal of the entire stock.

The first symptoms are inflammation of the mucous membranes (eyelids, genital area) which thicken and form small tumours. These tumorous nodules are found first on the tips of the ears and then all over the body. The tumours adhere closely to the skin and grow until they filially deform the whole head. Numerous nodules can be felt under the skin on the back.

Respiratory forms of the disease with no other symptoms also seem to be common. Clinical diagnosis is then impossible. Recovery is rare but not unheard of when the animal can eat and there is no secondary infection; however, the rabbit then becomes a healthy carrier of the virus.

There is no treatment, nor should there be. Vaccination is effective and can be done with a heterologous virus such as the Shope virus, which causes a small benign nodule in rabbits, or with a weakened form of the myxomatosis virus. In Western Europe the first is more popular, in Hungary the second. Prevention requires good hygiene and insect control, especially of lice and fleas in farm rabbitries.

Breeders or countries buying rabbits should ensure that the animals have been vaccinated for more than three weeks but less than two months before purchase, and that they come from a healthy rabbitry where regular vaccination is the rule.

Viral haemorrhagic disease (VHD)

There are many synonyms: RVHD (rabbit VHD), viral hepatitis, haemorrhagic hepatitis, X disease, etc.

Epidemiology. The epizootic form of this disease appeared in China in 1984 and spread rapidly throughout the world. By 1988, it had reached all of Europe and the American continent (Mexico, Venezuela, etc.).

The epizootic disease is most spectacular where farm rabbitries or wild rabbits are heavily concentrated. (In Italy, for instance, an estimated 80 percent or more of the farm rabbitries were entirely decimated within a few months.) One or two years later these epizootic forms appear less frequently and are less widespread, but the disease remains endemic.

However, when VHD hits a previously unaffected country, as in Cuba in 1993, the extent and evolution of the disease are dramatic. In general, animals over eight weeks old, particularly adults, are the most susceptible to VHD.

Frozen Chinese rabbit meat was the original source of contamination in Western Europe and Mexico. All producer countries of meat, by-products, breeding animals, etc. are now contaminated. Even though rabbit VHD spreads very quickly, few industrial production units in Europe except Spain were affected since they use only granulated feed. The forage collected by breeders is often suspected of being the principal vector of the virus.

Symptoms and lesions. When the disease appears in a rabbit production unit, it spreads immediately. Death occurs within three days after exposure and, in the chronic form, survivors recover in one week. The clinical symptoms are straightforward: fever, sudden death, sometimes preceded by convulsions and cries. Ante-mortem epistaxis is spectacular but not frequent. The disease is fairly easy to diagnose thanks to the dramatic mortality throughout the rabbitry (20 to 40 percent per day), particularly in adult rabbits.

The characteristic post-mortem lesions are:

- haemorrhagic syndrome throughout the respiratory apparatus, liver and intestine;

- congestion of the kidneys, spleen and thymus;

- frequently major enlargement of thymus and liver, the liver showing the most constant lesions, discoloration, a "cooked" appearance, very marked lobular patterns;

- clear failure of coagulation revealed by incision of the organs in fresh cadavers;

- necrotic hepatitis and general intravascular clotting in all organs, the most typical lesions revealed by histo-pathology.

Causes. Although the RNA virus which causes VHD has never been cultivated, most authors now agree that it should be classified in the family of the Caliciviridae. It is very resistant to freezing, ether, chloroform and proleolitic enzymes. It can be inactivated by formol or beta-propiolactone. It is destroyed by bleach, soda and the phenols.

The first target cells in the organism are those in the reticulo-endothelial system. The virus can subsequently be found in all cells, particularly the hepatocytes. Indeed, the purified virus used to produce inactivated-virus vaccines is taken from the liver.

Prevention and treatment. There is no treatment. Preventive hygiene measures have proved inefficient except in industrial-scale rabbitries. Several vaccines have been made from the inactivated viruses. They act very swiftly (two to five days) and confer six months of protection. In areas where the disease is endemic, vaccination is essential and effective. When an epidemic breaks out in a rabbitry in a region, immediate vaccination following the first fatality can save a production unit. The major problem in contaminated countries is having enough vaccine on hand to intervene immediately.

Two different policies are recommended for imported or new breeding animals (in addition to the standard measures such as quarantine): they are prior negative sero-logical test or vaccination. Neither is entirely reliable because the specificity of the test is low, and the disease has a very short incubation period. Vaccination would be the method of choice as the virus apparently does not multiply in vaccinated animals, but formal confirmation of this point is still pending.

Finally, despite the numerous similarities (virus, symptom, epidemiology), the disease European brown hare syndrome (EBHS) is not transmissible to rabbits and vice versa.

Foot pad abscesses

Foot pad abscesses are a very common complaint, familiar to all breeders. Chronic abscesses are far more frequent under the hind paws. They start as a barely visible swelling which can be felt by palpation. They may be limited to the cutaneous and conjunctive tissues. The skin becomes thick (parakeratosis) and scabby. Infection is latent and the sores may bleed. Poor cage floor hygiene can cause heavy secondary infection. The abscess then covers the whole metatarsus and becomes purulent.

These abscesses are found in farm rabbitries and in intensive production where mesh floors are used. Breeding animals are especially prone to this disorder. In farm rabbitries the main cause is poor upkeep of the straw litter, which becomes damp and rots. Various infections can follow (staphy-lococci, fungi) but the worst is a *Corynebacterium* (Schmorl bacillus) which gives rise to an evil-smelling necrotic gangrene which can spread to the head and the whole body and then to other animals (necrobacillosis).

This disease is rare where rabbits are raised on wire-mesh floors, but sore hocks (caused by staphylococcus) are much more common than in rabbitries where straw litter is used. Poor quality, rough or twisted wires, wrong mesh size (too wide) and rust are the main culprits, all fostering the development of foot pad abscesses. It is difficult to raise heavy rabbit breeds on wire mesh.

The control of foot and hock diseases is primarily preventive and consists of the following:

- choice of medium-weight breeds and animals whose foot pads are well furred to protect the skin, such as the New Zealand White and the Californian;

- use of thick, galvanized, welded wire mesh (mesh size 13 to 15 mm); it should not irritate the palm of the hand when rubbed;

- straw litter always kept dry and clean;

- frequent washing and disinfecting of cages.

Treatment is difficult. When there is no obvious suppuration the sores may be treated every day and then every two days with strong disinfectants such as iodine, Fehling liquor, paraffin oil and permanganate. The antifungoid action of iodine and permanganate is useful too in units using the litter system, which fosters complications with fungi. Antibiotic ointments are not recommended because the treatment is long and expensive and the ointments soften the skin. When the abscesses become purulent or the forepaws are affected the infection is then incurable and the animals should be culled. If other abscesses are noted, especially on the head (necrobacillosis), the bodies should be burned or buried deep. Foot pad abscesses make it practically impossible for males to mate.

Buck-teeth

Buck-teeth prevent the upper and lower incisors from touching and so they do not wear down. The incisors keep growing and eventually prevent the rabbit from eating. Buck-teeth may be hereditary (jaw malformation), or the result of injury (teeth broken against wire mesh). There is no connection with the type of feed - forage, hard granulated feeds and so on. The only prevention is breeding. Teeth should be carefully examined when buying or choosing a breeding animal. Treatment consists of cutting the teeth with sharp pliers right down to the gums every 15 to 21 days.

Ear and skin mange

Ear canker or mange is very common. It is a parasitic disease caused by a mite *(Psoroptes* or *Chorioptes)* and frequently complicated by bacterial infection. The symptoms are external otitis and yellow or brown scabs in the ear canal. The course of the disease can be very long. The scabs become waxy and invade the whole ear. The inside of the ear becomes scaly. The middle ear may then be affected, causing wryneck (the rabbit's head is held constantly to one side).

Treatment can be effective if the disease is caught in the very early stages, that is, as soon as small yellow-brown deposits are noticed in the ear. Insecticides are applied locally in the ear. Organophosphates such as malathion are preferable to organochlorines (DDT, lindane) which, although very active, are dangerous to humans. Glycerine, iodized oil or cresyl oil are also effective when applied frequently.

Prevention involves culling rabbits whose external ears are severely affected, and treating all other rabbits for several days running and then every fortnight. Throughout the treatment the straw litter must be changed frequently as the parasites can stay alive in the litter for a long time.

Ivermectine is unquestionably the drug of choice; two 200 mg injections per kilogram of live weight every eight hours provides a spectacular cure. The product is very persistent and if the stock is carefully treated at the same time and the rabbitry cleaned out, it will be effective for several months. This is a very strong medicine and should be reserved for breeders, for animals treated with it cannot be eaten for several months.

Skin mange is much less common. Today it is only found in poorly managed rabbitries. Lesions start at the edge of the lips, nostrils and eyes, spreading to the head and forepaws as rabbits frequently rub their heads. The skin dries, the hair falls out and the skin becomes scaly and finally scabby. The skin mange mites, *Sarcoptes* and *Notoedres,* are not of the same family as ear canker mites. Treatment is the same, but prevention measures (culling diseased rabbits, cleaning cages) must be stricter.

Skin diseases

Ringworm. Also called dermatomycosis or trichophytosis, ringworm is a skin and hair disorder. Not very common in farm rabbitries, it is widespread in intensive rabbit production. It starts with circular bald patches, usually on the nose. The hair looks clipped and the skin is irritated and inflamed. More small patches appear on the head, ears and forepaws and then over the whole body. On the oldest lesions the hair can be seen growing again in the centre.

It is a very contagious infestation that can sometimes be transmitted to humans, although it is more commonly transmitted to other domestic animals such as dogs and cats. Ringworm is caused by microscopic fungi that can belong to different genera *(Trichophyton,* *Microsporum, Achorion)* and are not specific to rabbits. There is no economic loss as long as infestation is light.

Treatment is long and costly. An antimycotic, Griseofulvin, is administered in the feed for about ten days. During treatment all equipment should be frequently cleaned and disinfected in a 5 percent formol solution. Many producers, successfully it seems, sprinkle powdered sulphur (sulphur flowers) on the ground, cages and nesting boxes. In small rabbitries local treatment can be applied with antimycotics in powder or liquid (tincture of iodine and other dyes), but preventive hygiene should accompany the treatment. Badly afflicted animals should be culled and domestic animals treated.

Ectoparasites and trichophagy*.* As well as the lice and fleas that are specific to rabbits, ectoparasites of other animal species, particularly poultry, can also bother rabbits. Not found in intensive rabbit production, these farm rabbitry ectoparasites can harm production and, worst of all, they are the vectors of many disease agents, including the myxomatosis virus. With good hygiene and external antiparasitic preparations they can be rapidly eliminated.

Trichophagy or fur-eating occurs both in farm rabbitries and in units using wire-mesh floors. The animals eat each other's fur and end up with bare backs and flanks. All sorts of diagnoses have been advanced: unbalanced rations, behavioural problems, unsuitable environment, amount of light, overpopulation, genetics and so forth. It was very widespread when wire-mesh cages were first used extensively, but seems to be declining with the general improvement in production conditions (equipment, feed, strain). There is no exact preventive measure and no specific treatment.

Zoonoses

Zoonoses are diseases shared by many animal species and humans. Most have no special feature peculiar to rabbits and are rarely contracted by them (rabies, tetanus, etc.). Therefore only a few are mentioned here, either because they can be dangerous to people or because the appearance of the disease in the rabbit reveals its existence on the farm or in the village.

Tuberculosis

This disease is very rarely reported in rabbits. Nevertheless it does exist and may be of avian, bovine or human origin, in decreasing order of frequency. The rabbit is very resistant to tuberculosis, so the disease evolves very slowly. The lesions, which are the sole indication of tuberculosis, can only be seen in breeding animals. The main organs affected are the lungs and less frequently the liver, intestine and kidneys. The spleen is very rarely affected. The classic tubercular nodules are found in the parenchyma of these organs, often containing an almost solid cheese-like pus.

Pseudotuberculosis

This is more common in guinea-pigs, wild rabbits and hares than in domestic rabbits reared on straw litter. It has almost disappeared with modern wire-mesh cage production. Pseudotuberculosis is one cause of synovial arthritis in humans. The germ *Yersinia pseudotuberculosis* provokes numerous whitish nodular lesions on the intestinal viscera, especially the spleen, which become enlarged. These nodules, ranging in size from a lentil to a chickpea, are sometimes amalgamated. They are scattered throughout the abdominal cavity but are rarely found in the lungs. Apart from steady weight loss there are no symptoms to diagnose. The disease can easily be recognized by post-mortem examination.

Tularaemia (rabbit fever)

This very contagious disease is common in hares, but rabbits seldom contract it. Its significance is the danger it represents for humans. A bacterial disease caused by *Francisella tularensis,* it gives rise to high fever, leaving the animals in a semicomatose state. Lesions are enlargement and congestion of the spleen. The liver is often dotted with numerous tiny greyish-white spots (miliary necrosis) about the size of a grain of millet.

Listeriosis

This disease is less rare than tularaemia, and still appears sporadically in farm rabbitries. A septicaemic disease caused by *Listeria monocytogenes,* it is very difficult to diagnose clinically. Listeriosis should be suspected when the following symptoms appear on the farm:

- nervous upsets: photophobia, spasms, wryneck;
- abortions in does or ewes;

- miliary necrosis of the liver and spleen (without enlargement).

Toxoplasmosis

This disease is unquestionably more common in farm rabbitries than is generally believed. It is caused by the intermediary stage of an internal cat and dog parasite, *Isospora.* The course of the disease does not usually produce symptoms, although there may be jerky nervous reactions. The lesions are translucent cysts in the brain and in muscles or viscera. Often the spleen is enlarged.

Conclusion

Zoonoses are infrequent in farm rabbitries and have apparently never been identified in intensive rabbit production. This is because contamination is usually spread by forages polluted by other animal species. Zoonoses are also usually diseases of adult animals; the early slaughter of animals (10 to 12 weeks) limits their spread. When these diseases are suspected the dead animals should be burned or buried and human hygiene intensified. Although antibiotic treatment may be effective in certain cases it is best not to treat but to cull the entire stock. Good hygiene is the only prevention. Apart from the usual rules of cleanliness, forage must be cut and stored with special care. Rats and mice are formidable propagators of these diseases. Rat extermination around rabbitries is fundamental.

Trypanosomiasis

There are few data on this disease. Various findings from Africa on the subject, while not contradictory, are not uniform. It has been demonstrated that rabbits can contract trypanosomiasis experimentally or in special circumstances. They are particularly susceptible to *Trypanosoma brucei.*

There are reportedly some rabbitries in tsetse fly areas, for instance in Côte d'Ivoire, with no recorded cases of spontaneous outbreaks of trypanosomiasis in rabbits. Trypanosomiasis has caused some problems in Mozambique, however. It has been reported that its symptoms are oddly like those of myxomatosis.

> ***Note:*** Other diseases that are transmissible from rabbits to humans, or common to both, have already been mentioned. By contrast, neither rabbit variola (pox virus) nor rabbit

syphilis *(Treponema cuniculi)* can be transmitted to humans.

Reproductive diseases and disorders

A doe can produce over 60 young in one year, but few breeders are in a position or context to exploit this potential fully. Rabbit maternities are the source of many disease problems. The breeder should focus efforts on the nursery and on maternal health, the prime guarantee of obtaining healthy young rabbits at weaning. Productivity factors in the rabbitry (frequency of mating, litter size, age at weaning) depend at least as much on the breeder, equipment, feed quality and quantity as on the female rabbit's potential.

Maternal health determines the survival of the offspring

All the diseases mentioned above can affect breeding females. Only a few points peculiar to reproduction will be mentioned in the following paragraphs and the relative importance of the major diseases of females will be discussed in order of importance.

Respiratory infections

Respiratory ailments are the main disorders affecting pregnant rabbits in closed rearing. In intensive production, apart from the environmental causes described earlier, lactation must be added as a contributing cause. In young nursing does, hard-to-diagnose ailments can be complicated by acute or subacute pneumonia. The doe may die before weaning her litter or she may have to be culled shortly afterwards.

Digestive disorders and enterotoxaemia

Digestive diseases are far less serious in adult animals than in growing rabbits. The classic coccidiosis-type diarrhoea is rare in adults. Intestinal parasitism (coccidiosis, strongylosis) will be latent or chronic, fostering the appearance of other diseases.

Enterotoxaemia is more common, especially in farm rabbitries. It can develop very rapidly (one to seven days) with or without mucoid enteritis. Most often it occurs in late pregnancy or mid-lactation, sometimes in association with symptoms of acute pneumonia. In traditional rabbitries, complications of paresis or paraplegia are common, especially in fat, overfed does working at low-intensity breeding rates. Control in this case involves adapting the reproduction rate to the feeding capacities of the production unit. There is no treatment.

Metabolic disorders

Some 25 to 30 percent of does in intensive production die, usually with no warning symptoms. Mortality occurs in mid-lactation in young first- and second-litter females and in the latter stages of pregnancy in older does. Often called enterotoxaemia, this illness is certainly not of infectious origin, although bacterial complications are common. It is rather more like a metabolic disorder, such as milk fever in ruminants or eclampsia in women. Its aetiology is still not clear. There is no curative treatment. Mortality can sometimes be reduced by preventive doses of calcium in drinking-water or parenteral injections (Ca gluconate) just before kindling.

Abscesses and mastitis

Abscesses are very common in rabbits. They sometimes grow to enormous size, and develop very quickly without any apparent change in the animal's health. There are two preferential sites in does: the sub-maxillary area and the teats. These and foot abscesses are the main reasons for culling breeding does.

Most often the cause is *Staphylococcus aureus,* but other germs may be present. The worst are pasteurella, which can make the disease epizootic and lead to numerous complications (pneumonia, septicaemia, abortion). Mastitis is common in units with mesh floors and is probably fostered by congestion caused by chilling. When mastitis is in the congestive stage (hard, reddened mammary gland but no pus) the disease may be staved off by a three-day antibiotic treatment and the local application of astringents (vinegar) twice daily to aid decongestion. It is uneconomical to treat abscesses or purulent mastitis.

Chlamydiosis

Clamydia psittaci is found in rabbits. The clinical symptoms are many: refusal of the male, early miscarriage, peri-partum haemorrhage, hydrocephalus and poor viability of newborn rabbits. Tetracycline as a preventive measure for the entire rabbitry is efficient but there may be relapses.

Genital infections

External genital organs. The external genital organs (vulva, penis, scrotum) can be the site of specific venereal diseases. The best known is rabbit syphilis or vent disease, caused by a spirochete *(Treponema cuniculi).* It has never been reported in intensive rabbit production, but vent disease is not exceptional in rural rabbitries. Inflamed lesions become ulcerated. Bucks are often affected (orchitis, balanitis) and transmit the disease, which can turn enzootic. This is a benign disease which impedes mating; it can easily be treated with antibiotics (penicillin, tetracycline).

This disease can be confused with the onset of myxomatosis!

***Internal genital organs**.* The internal genital organs can also become infected. These, far more serious, far more common infections make reproduction impossible.

Metritis or white discharge, a uterine infection, is often associated with mastitis and respiratory complaints. It is a major rabbit disease. One symptom of metritis is an abnormal frequency of sterile does and mastitis in the rabbitry. Abortion, which is usually rare, may become more common. Metritis shows up at post mortem: the uterus is thickened and poorly retracted and there may be abscesses at the last embryo implantation site, sometimes covering the whole uterus (pyometra).

Aetiology is complex. Gestation and kindling are obviously contributing causes, but hygiene is a determining factor, and a chronic pasteurellosis in the rabbitry could be the culprit. The most common germs are non-specific: staphylococci, pasteurella. The specific germs such as toxoplasm, *Listeria* and *Salmonella* are much less common. Specific infections are likely if there is widespread abortion.

Antibiotics can be given, especially at the onset of the disease. But they will not be effective unless the most advanced cases, such as very thin does, or does with purulent mastitis or symptoms of pneumonia or purulent coryza, are culled. Preventive medicine, in this case vaccination, is only valid for pasteurellosis (see section on respiratory diseases). Preventive hygiene is decisive in controlling internal genital diseases.

Non-infectious reproduction problems

Sterility. Absolute sterility is relatively rare. "Sterility epidemics" are usually seasonal and can often be traced to insufficient light (less than 14 to 16 hours). Sterility otherwise occurs after one or several kindlings (see previous chapter). Does serviced three times with no results should be culled for both hygiene and economy.

***Twisted uterus**.* Cases of twisted uterus are not uncommon. This is discovered during post mortems on does that died during gestation. The causes are not clear. Overcrowding of the uterus and disturbance of does are frequent explanations.

Delayed birth. Delayed birth often occurs with small litters (one to three). Foetal retention is common in this case, invalidating the doe economically. In modern production, birth is systematically induced by injections of oxytocin on day 33 of pregnancy (servicing on day zero).

Parturition outside the nest box. Young first-litter females are the usual offenders. Disturbances, or mice in the nesting box, are possible causes.

***Prolapsus of the vagina**.* There is no treatment for prolapsus of the vagina.

Cannibalism. Real cannibalism caused by abnormal behaviour in the doe is exceptional. The female usually eats only those young which are already virtually dead but still warm. This may happen a few hours or days after parturition. Insufficient drinking-water after parturition is considered a cause in farm rabbitries, and this could well be the true reason.

Abandonment of the litter. This is most often done by young females whose milk has not let down, or has let down too late. A doe that abandons two litters should be culled.

The nest and young rabbit mortality

Compared with other domestic animals, rabbits are still virtually in the foetal stage at birth. The survival of newborn rabbits, and hence the success of the rabbitry, is closely related to the quality and hygiene of the litter's immediate environment.

If the amount and type of materials used for the nest (straw, wood shavings, hay, etc.) are inadequate during the first few days, the newborn rabbits will get cold and death is then inevitable. The doe does little to intervene. She pulls fur to help make the nest; she nurses her young once a day and sometimes she will defend access to the nest, but she does not care directly for the young. If the nest box is poorly designed and the young are able to get out after the first few days, the doe will not put them back.

If nest hygiene is poor (droppings, dampness) or if the mother is sick (mastitis, coryza) the young will develop a nostril-blocking rhinitis which will impair their sense of smell within a few hours. Their sense of smell is crucial as it guides them to the mother's teats. Small staphylococcic abscesses can quickly develop on the young rabbits' bodies (belly, groin, tarsus) under these conditions.

In modern French rabbitries with highly prolific does, an intensive reproduction system and adequate environmental conditions, an estimated 5 to 7 percent of the young are still-born and another 16 to 20 percent normally die before weaning. About a third of this mortality is accounted for by precocious dam mortality. Some of the young can be saved by fostering two or three to another nursing doe with young of the same age. The remainder of the losses take place during the first two weeks of lactation. Occasionally an entire litter is lost during the first four or five days.

The aetiology of these mortalities is not known, but it seems to have more to do with the doe's state (lactation?) than with any particular disease of the newborn rabbits. The above figures indicate that a mortality rate of less than 15 to 20 percent should not be considered catastrophic. On the other hand, after the first 15 to 20 days of lactation young rabbit mortality should be very low. If it is not, the dam should be examined for mastitis or coryza. Cage and nest-box hygiene should be checked. Pre-weaning diarrhoea (30 to 35 days) is a sign of inadequate hygiene. Coccidiosis indicates very poor hygiene.

Preventive hygiene

The word prevention has been constantly repeated throughout this chapter as essential for successful rabbit production. Careful hygiene is usually enough to prevent major disease crises. Preventive medicines (vaccinations, anticoccidiosis treatments, etc.) have been described. They are not widely used in rabbit production. The basic rules of preventive hygiene are now set down in detail.

Location and design of the rabbitry

It has been emphasized from the outset that rabbits must have an environment in which they do not constantly have to withstand external disturbances and aggression. The rabbitry should be located whenever possible far from such nuisances as noise and dust (dust carries microbes), sheltered from the prevailing winds and, in hot countries, shaded from the sun. Rat and mice extermination should be considered, as both are formidable healthy carriers of diseases to which rabbits are susceptible.

Cleaning should be constantly kept in mind in the designing and building of a rabbitry. Nothing that cannot easily be cleaned and disinfected should be allowed. The rabbit's immediate surroundings (cage, feeding racks and drinkers in particular) should be portable, so they can be regularly removed, cleaned, dried and disinfected. In completely closed buildings the ventilation system should be carefully designed for flow without draught. Where ventilation is used, forced-air ventilation is preferable, as it keeps insects out and makes it possible to control the air flow by adding or removing vents.

Some authors insist that in tropical countries the interior of the building should be sufficiently protected to act as a buffer against extremes in temperature and humidity, especially during the rainy season, to cut down the incidence of pulmonary diseases. As an example, a rabbitry in Burkina Faso built with local materials (laterite bricks, palm framework, straw roofing) recorded a much lower range in temperature variations than did a "strong" building made of construction blocks with a tin roof. Where possible, metal should be used for the wire-mesh hutch and accessories as it is the easiest material to clean and disinfect.

Constant hygiene

Preventive hygiene. The rabbit's excitability is a contributing factor in illness. Casual visitors such as feed suppliers, rabbit buyers and other breeders (who are vectors of diseases from other rabbitries) should be barred. Rabbits should be protected against dogs, cats and small wild carnivores.

Feed and water hygiene is basic as both can carry numerous agents of rabbit diseases (e.g. coccidiosis and worms). Feed should be stored out of the reach of domestic animals. It should be distributed in troughs or racks, but never on the ground. Drinkers should never be set on the ground. Rabbits drink a lot of water, but they will not drink dirty water. Water is the ideal medium for coccidia sporulation. Accordingly it should be changed and drinkers cleaned often.

Cage and nest hygiene is particularly important while the does are nursing. In wire-mesh hutches the cage must be removed and cleaned after each kindling. In farm rabbitries the straw litter must be renewed often. After kindling, any stillborn young should be removed from the nest and the nest remade if necessary. Contrary to widespread belief, a doe will not abandon her young if they have been touched. It is only necessary to keep the doe out of the nest during the cleaning operation.

After weaning, if straw litter is used, it should be kept clean and dry. The more animals per cage, the more difficult this is. In every type of production system weaning demands scrupulously clean, disinfected, dry cages. Weaning is one of the crucial moments in rabbit production. Transporting the animals, mixing up litters and using questionable cages should be avoided. Successful production depends on these details.

Microbial infection. It is also necessary to work constantly against any buildup of microbial infection. Chronically sick animals (with coryza, pneumonia, mastitis, abscesses), especially breeding animals, must be culled. One sick breeding animal in a rabbitry is of small value in relation to the danger it represents for the rest of the stock, the cost and uncertain outcome of treatment and the possibility of its quick replacement (sexual maturity at four months).

In completely closed buildings the control of microbial contamination should include the maintenance of walls, ceilings and especially floors. Damp or dusty floors are a permanent source of air pollution.

Early slaughter. Early slaughter (10 to 12 weeks) of animals for market is also a form of preventive hygiene. Many diseases take several months to develop before becoming contagious, especially in small or farm rabbitries.

Human factor. People are the most dangerous permanent vector of disease. They can bring in contaminants from the outside and so should wash their hands before entering and don footgear and a smock which always remain inside the rabbitry. Only a human being can palpate a doe suffering from mastitis and then systematically go on to infect all the mammary glands of the females to be palpated that day. Clean hands are extremely important, especially when handling animals and distributing feed and forage.

Preventive medicines to control parasitic diseases also help to maintain a healthy environment. Many parasites undermine the animals' state of health without causing directly perceptible losses and pave the way for a great variety of infections. However, the systematic use of antibiotics as a preventive measure is definitely not recommended. The abuse of antiparasitic drugs, especially of sulpha drugs, does far more harm than good. All drugs, at a certain dose, are poisons and must be used with caution.

Disinfecting*.* The literature covers this topic extensively, so the following will be brief. Disinfecting the rabbitry should be a routine matter, following some simple rules regarding cleanliness, dryness and disinfection. Dirty equipment cannot be disinfected. It must be washed first or, if water is short, carefully scraped and brushed. It must then be thoroughly dried as a first step towards disinfecting equipment. It should not be forgotten in this context that sun-drying well-cleaned equipment for several days is a simple, cost-free and very efficient means of disinfecting. The only preconditions are a storage area off limits to domestic animals and a reserve supply of extra equipment so that cleaning and disinfecting time will not cut into production time. In industrial production, pressurized steam-cleaning equipment is indispensable.

Occasional measure: sanitary isolation

No matter what precautions are taken, after one, two or three years health problems will become less and less easy to control. Imperceptibly, productivity will decrease despite an increase in hygiene and care and in the experience of the breeder. This has to do with the buildup of bacterial contamination in the rabbitry, coupled with the irreversible presence of harmful micro-flora and microfauna in the animals.

Sanitary isolation becomes essential at this point. All rabbits in the affected section of the rabbitry must be culled. All equipment must be cleaned, repaired and disinfected. After this is done the area must be left vacant for some time (one or two weeks) before introducing new rabbits. Some small farm rabbitries have two premises which they alternate every year. This is a kind of one-year sanitary isolation which has proved very effective.

Colour plates

***1 New Zealand White rabbit* (Foto Saleil)**

***2 Bouscat Giant White rabbit* (Foto Saleil)**

***3 French Belier rabbit* (Foto Saleil)**

***4 Californian rabbit* (Foto Saleil)**

***5 Dutch Belted rabbit* (Foto Saleil)**

***6 French Giant Papillon rabbit* (Foto Saleil)**

***7 Vienna Blue rabbit* (Foto Saleil)**

***8 Flemish Giant rabbit* (Foto Weber)**

***9 Creole (Guadeloupe) rabbits* (Foto Lebas)**

***10 A "family package" of bucks and breeding does supplied by a Mexican programme* (Foto Lebas)**

***11 Wooden hutches with mesh floors arranged in a two-storey system (Guadeloupe)* (Foto Lebas)**

***12 Open drinkers supplied semi-automatically from a fitted bucket (Guadeloupe)* (Foto Lebas)**

***13 Fattening cages built entirely in wire mesh, placed outside in superimposed rows (France)* (Foto Lebas)**

***14 Cages arranged in a plastic greenhouse, protected with a reed lattice (France)* (Foto Lebas)**

***15 Exterior of the same greenhouse, photographed in winter* (Foto Tudela)**

***16 Fattening cages for rabbits in a greenhouse with a makeshift floor* (Foto Saleil INRA)**

***17 Italian system for arrangement of fattening cages* (Foto**

***25 Rabbitry with semi-underground cages: unit* (Foto Finzi)**

***26 Faeces from rabbits receiving feed with a normal proportion of roughage, slightly deficient and deficient in roughage but without diarrhoea* (Foto Colin)**

Chapter 6 HOUSING AND EQUIPMENT

Biological considerations

The design of rabbit housing is governed by the behavioural characteristics of the animals and their reactions to environmental temperature and humidity.

Rabbit behaviour

Some kinds of behaviour have already been analysed in this book and others have been mentioned briefly. They all have an influence on rabbit housing so they will be summarized at this point. Since the domestication of the rabbit is recent in terms of species evolution (200 to 300 generations at most) the behaviour of the domestic rabbit is still much like that of the wild rabbit. The reactions of wild rabbits will often provide explanations for the problems of housing domestic rabbits and suggest ways of solving them.

Territorial behaviour. Wild rabbits live in sedentary fashion in a territory the size of which depends on the conditions of food supply. They mark their territory, their fellows and their offspring with the aid of a gland found in hair follicles under the chin. The bucks also mark off their territory with their urine. The rabbits dig burrows in which they take shelter at the slightest sign of warning. There they live in a "society". Before parturition, however, the doe digs a special burrow where her young are born and where she returns once a day to nurse them.

This is why domestic rabbits should have durable living quarters, providing either a refuge from disturbances or a peaceful environment that makes a refuge unnecessary. Any new and sudden change (noise, presence, smell) will make the first rabbit in the group to notice the disquieting novelty thump his hind foot to warn his fellows of danger. To prevent panic in the rabbitry the breeder should take care that changes that might upset the animals are avoided.

When a rabbit is put in a new cage he will explore it and then mark it with his smell. The more strange odours there are in the cage the longer this task will take.

The burrow is not only a refuge in case of alert, it is also a rest area during the day, as rabbits are mostly nocturnal. Temperature and humidity are far more constant in the burrow than outside.

***Social behaviour**.* Wild rabbits live in colonies in which females outnumber males. Each female, with or without offspring, attacks the young of other does. Bucks act as moderators at this stage. When the young males reach puberty, however, the adult males try to eliminate them as rivals by castrating them.

The method used in rational European rabbit production to prevent such conflicts is to isolate each adult rabbit in an individual cage. Before puberty, young rabbits can be reared in groups. Attempts to rear breeding animals in groups are bound to fail because the does are so aggressive towards the young, especially when the animals' living space is cramped. Females without young can be reared in groups provided each female has at least half a square metre of space for herself.

***Sexual behaviour**.* Ovulation in the does is brought on by mating (see Chapter 3, Reproduction), so one might expect mating to be possible on a quasi-permanent basis. In fact, does do have a behavioural cycle of acceptance of the male but unfortunately this varies greatly from one doe to the next. Attempts at servicing often have to be repeated, which means the animals must be moved about a great deal.

The buck is so very territorial that when he is put in a female's cage his first act is to mark this new territory with his smell, while the doe tries to eliminate the intruder. But if a doe is put in a buck's cage the immediate reaction of both animals is sexual. For a receptive doe preparation for mating takes 20 to 120 seconds, and the act itself less than a second. For servicing, therefore, it is the doe that should be moved. This is relatively easy because does are calmer and weigh less than bucks (3 to 6 kg). For mating to be supervised, the animals need to be visible in all parts of the cage. Access to the buck's cage should be simple so that the does can be easily introduced and removed.

With this kind of mating, people have to move the animals physically within the rabbitry and this will influence the planning of the general layout of the unit to limit the distances to be covered. The rather unsatisfactory results obtained with special cages reserved for mating should be mentioned. Many males waste a lot of time marking a mating cage that is impregnated with the smell of their predecessor, and the cage is also a possible site for the spread of diseases.

Maternal behaviour. Before kindling, the doe makes a nest with various materials plus fur that she pulls from her abdomen. The wild doe's nest is made at the end of the private burrow she digs for kindling. The domestic rabbit does not usually have the opportunity to do this, so a private area should be set apart for her. In farm rabbitries using straw litter the doe might be satisfied to dig into the straw to make a nest. But producers have noticed that it is preferable to provide her with a nest box that approximates the natural burrow.

A box like this is useful in a farm rabbitry and essential in wire cage production. After the young are born (six to 12 per litter), the doe nurses them once every 24 hours for about a month. To allow the motor coordination and heat-regulation capacity of the baby rabbits to develop, the nesting box should be maintained for at least two weeks. It should be big enough to accommodate the doe and her litter during nursing.

Feeding behaviour. Laboratory research has shown that rabbits will drink and eat at any time in the 24 hours, although they tend to feed nocturnally. Intake is rather slow, even if the animals' feed is rationed. Feed and water should therefore be available over periods of several hours, whether feed is rationed or ad lib. The feed must not be allowed to get dirty, which is inevitable if it is strewn on the ground (see Chapter 5, Pathology).

From the age of three weeks young rabbits begin to eat the same feed as the doe. Their small size allows them to slip easily into forage racks or dry feed hoppers, so this equipment must be designed to keep them out.

Practically speaking, these features mean that the breeder must provide a drinker and feeding rack for each cage, and perhaps a fodder rack. The animal must be able to reach the feeders and fodder racks, as must the caretaker to top them up frequently. An automatic or semi-automatic drinker is easy to make, however. These constraints mean that solid feed distributors are almost always placed in front of the cages, which can easily hinder visibility and accessibility.

Hygiene, habitat and breeds

There would be no point in reiterating here all the rules of hygiene dealt with in other chapters, particularly preventive hygiene. However, the design of the rabbitry will be heavily influenced by some of these rules.

One of the major rabbit diseases in traditional small-scale production using straw litter is coccidiosis. Contamination is via oocysts eliminated with the faeces. Breeders have cut the incidence of this disease by using wire-mesh floors through which the excrement drops.

The wire-mesh flooring system, combined more recently with single, portable, interchangeable cages, has led to considerable progress in disinfecting equipment. Some diseases have been cut down or even wholly eliminated. But not all rabbit breeds can adapt to this type of flooring. Heavy or nervous breeds, in particular, are subject to sore hocks, a bacterial infection developing on the foot pads and irritated by the wire mesh (too much weight per cm^2). The risk is greater when the animals are raised in environments with high temperatures (31° to 32°C), or very high humidity (constant relative humidity above 85 percent), or when the rabbits are frequently under stress and thus thump their hind feet on the ground to warn the other rabbits of impending danger. A mesh floor also cannot be insulated, and rabbits are more liable to respiratory ailments if air flow is not controlled.

Breeders therefore have to make a decision: either they rear New

Zealand White or Californian breeds, which have been adapted to mesh flooring, and thus meet modern hygiene standards, or else they rear heavier or more excitable breeds - but then how do they control coccidiosis and other diseases?

As well as these hygiene-linked problems there are other advantages and disadvantages with both mesh floors and traditional straw litter. With a mesh floor, through which droppings can fall, automated or very infrequent cleaning is possible because droppings accumulate under the cage). But it also makes the rabbits very dependent on the microclimate or ventilation in the rabbitry. Straw litter, on the other hand, has to be cleaned often (at least once a week) so the producer has to have the material on hand (straw, wood shavings, etc.). An advantage is that a cage with a straw litter floor can be put almost anywhere, as the cage itself partly insulates the animals from variations in the external climate.

In Europe today most new production units use solely wire-mesh cages and New Zealand White or Californian rabbits. But this implies doing without the genetic pool of other breeds. Would it not be possible to design other types of flooring, recognizing that slatted floors have never been very satisfactory? Whatever the answer, for many developing countries the wire-mesh cage will probably remain a theoretical solution for many years to come, until the special mesh necessary is made available to producers at reasonable prices.

Environment

Temperature. Temperature is the most important factor as it directly affects a number of elements. Rabbits have a constant internal (rectal) temperature so heat production and losses must vary to maintain body temperature (Table 49). They do this by modifying their feed intake level (regulating production), as described in the chapter on nutrition. They use three devices to modify heat loss: general body position, breathing rate and peripheral temperature, especially ear temperature (Table 49).

If the ambient temperature is low (below 10°C) the animals curl up to minimize the total area losing heat and lower their ear temperature. If the temperature is high (above 25° to 30°C), the animals stretch out so they can lose as much heat as possible by radiation and convection, and step up their ear temperature. The ears function like a car radiator. The efficiency of the cooling system depends on the air speed around the animal. At the same time the animal pants to increase heat loss through evaporation of water (latent heat). The sweat glands are not functional in rabbits and the only controlled means of latent heat evacuation is by altering the breathing rate. Perspiration (the evacuation of water through skin) is never great because of the fur.

TABLE 49 Exportation of heat, rectal temperature and ear temperature in adult New Zealand White rabbits, according to ambient temperature

Ambient temperature (°C)	Total release of heat (*W/kg*)	Release of latent heat (*W/kg*)	Body temperature (°*C*)	Ear temperature (°C)
5	5.3 ± 0.93	0.54 ± 0.16	39.3 ± 0.3	9.6 ± 1.0
10	4.5 ± 0.84	0.57 ± 0.15	39.2 ± 0.2	14.1 ± 0.8
15	3.7 ± 0.78	0.58 + 0.17	39.1 ± 0.1	18.7 ± 0.6
20	3.5 ± 0.76	0.79 ± 0.22	39.0 ± 0.3	23.2 ± 0.9
25	3.2 ± 0.32	1.01 ± 0.23	39.1 ± 0.4	30.2 ± 2.5

30	3.1 ± 0.35	1.26 ± 0.38	39.1 ± 0.3	37.2 ± 0.7
35	3.7 ± 0.35	2.00 ± 0.38	40.5 ± 0.8	39.4 ± 0.47

Source: Gonzales, Kluger and Hardy, 1971.

These systems work between 0° and 30°C but when ambient temperatures reach (and mainly when they exceed) 35°C rabbits can no longer regulate their internal temperature and hyperthermia sets in.

The regulation methods described above, based on observations of adult animals, are applicable to young rabbits from the age of about one month, when they can move about and feed themselves and the juvenile coat has grown. Heat regulation of newborn rabbits is somewhat different: they have no fur and cannot correctly adjust their food intake as the doe's milk output is the result of an involuntary reaction. At birth they have rather good fat reserves which help them maintain body temperature if two conditions are met. The surrounding temperature must be at least 28°C (30° to 32°C if possible), and they must have other young to huddle against to reduce heat loss.

At birth, young rabbits cannot modify their body shape by curling up.

The only way they can limit heat loss through convection and radiation is to huddle together with the other young in the litter. In fact, if ambient temperature varies during the day the young rabbits will move apart when the temperature is high and huddle back together when it goes down. But a sudden temperature drop may well exhaust their thermoregulation potential before they can get back in the huddle and they can die of cold 10 cm away from the group. The new-born rabbit is blind and the incomplete myelinization of the nervous system that governs motor control hampers coordinated movement. The producer must make sure the temperature in the nest remains constant to prevent this sort of accident.

Humidity. Rabbits are sensitive to very low humidity (below 55 percent) but not to very high humidity. This may be explained by the fact that wild rabbits spend much of their lives in underground burrows with a humidity level near saturation point (100 percent).

The rabbit has more to fear from abrupt changes in humidity. Constant humidity is therefore the best solution, and this will depend on the housing design. French breeders find 60 to 65 percent humidity levels successful, using only auxiliary heating in winter.

While the humidity level does not seem to trouble the rabbit in moderate temperatures, this is not so with temperature extremes.

When the temperature is too high (close to the rabbit's body temperature) and humidity is also high, not much latent heat can be exported as water vapour through evaporation. The result is discomfort which can be followed by prostration. Very hot spells with near 100 percent humidity can cause serious problems. Unfortunately this is common in tropical climates during the rainy season.

When the temperature is too low and humidity close to saturation point, water condenses on poorly insulated walls, especially at so-called "heat bridges". Water is a good heat conductor and so the cold becomes more penetrating, causing heat loss in the animals through convection and conduction. Digestive and respiratory disorders often follow. When the surrounding air is cold, excess humidity modifies the secretion and viscosity of the mucus protecting the upper respiratory apparatus.

Air which is too dry (below 60 percent relative humidity) and too hot is even more dangerous. Not only does it upset the secretion of mucus but the ensuing evaporation shrinks the size of the droplets carrying infection agents, enabling them to penetrate more easily the respiratory apparatus.

Ventilation. The rabbitry must have a certain minimum of ventilation to evacuate the harmful gases given off by the rabbits (CO_2), to renew the oxygen and get rid of excess humidity (evaporation, exhalation) and excess heat given off by the rabbits.

Ventilation needs can vary enormously, depending especially on climate, cage type and population density. Ventilation standards for temperate climates based on several French studies are given in Table 50. This table combines the various parameters (temperature, air flow, humidity) to determine optimum air flow per kg of rabbit live weight. If there is an imbalance, especially between air flow and temperature, accidents like those illustrated in Figure 24 occur.

It is relatively easy and cheap to measure temperature and humidity, but exact air flow measurement requires sophisticated, expensive, hard-to-get equipment such as a hot-wire anemometer (a revolving-cup anemometer is not sensitive enough). However, the producer can estimate the rate of air flow near rabbits by using a candle flame, as shown in Figure 25.

High ammonia air levels, 20 to 30 parts per million (ppm), greatly weaken the rabbits' upper respiratory tract and open the door to bacteria such as pasteurella and bordetella. To keep NH_3 levels down, ventilation can be increased. The risk is then overventilation, with all the negative consequences illustrated in Figure 24. A more effective solution is to limit NH_3 production from fermenting floor litter (droppings and urine) by removing the litter quickly or keeping it dry. The maximum permissible NH_3 content in the air rabbits breathe is 5 ppm.

Lighting

Few studies have been made on the influence of light on rabbits, and these are almost exclusively concerned with the duration of lighting and seldom with light intensity. Furthermore, practical recommendations on lighting are based more on observations in rabbitries than on experimental findings.

Exposure to light for eight out of 24 hours favours spermatogenesis and sexual activity in bucks. Conversely, exposure for 14 to 16 hours a day favours female sexual activity and fertilization. In rational European production all breeding animals of both sexes get 16 hours of light. The slight drop in male sexual activity is amply compensated by good female reproduction rates (acceptance of the male and fertilization).

TABLE 50 Ventilation standards in France for enclosed rabbitries

Temperature (°C)	Humidity (%)	Air speed (m/sec)	Air flow (m^3/h/kg live weight)
12-15	60-65	0.10-0.15	1-1.5
16-18	70-75	0.15-0.20	2-2.5
19-22	75-80	0.20-0.30	3-3.5
23-25	80	0.30-0.40	3.5-4

Source: Morisse, 1981.

Performance is more constant in windowless rabbitries with artificial lighting than in rabbitries which supplement sunlight by artificial lighting. Twenty-four-hour light trials caused reproduction disturbances in rabbits. It therefore seems best to limit the duration to 16 hours.

Observations from different rabbitries indicate that breeding does need considerable luminosity, at least 30 to 40 lux. In fact, many breeders who light their premises for 16 hours a day but not uniformly find that the does receiving the least light have the worst reproduction performance. When light distribution is made uniform, reproduction performance picks up.

In European rabbitries lighting is provided by incandescent lamps or fluorescent tubes (neon daylight type). The latter provide the necessary lux at a lower energy cost than incandescent lamps, but their installation cost is much higher. For flat-deck units the power consumption is 3 to 5 watts per square metre with light sources located no more than three metres from the animals.

Very young rabbits do not really need light, but 15 to 16 hours per day do no harm. Twenty-four-hour lighting, however, can cause disturbances which are hard to explain, such as diarrhoea unrelated to changes in the rate of caecotrophy. So breeders use either sunlight (in rabbitries with windows) or artificial lighting for one or two hours a day to satisfy the young rabbits' needs, at a set time so as not to disturb caecotrophic behaviour. A much weaker light (5 to 10 lux) can be used for young rabbits.

Rabbitry equipment

Equipment in direct contact with the rabbits or their excrement becomes contaminated by the bacteria, viruses and fungi that accompany the animals. Cages, fittings and building walls must be designed so they can be easily cleaned, disinfected or replaced and not in turn become sources of contamination.

Portable components which can be cleaned outside the rabbitry building are especially recommended. Away from the rabbits stronger cleaning agents and more effective methods can be used - powerful disinfectants, lengthy soaking, prolonged exposure to the sun's rays.

Some materials are easier to disinfect than others. Wood is very hard to clean, but it can be periodically replaced in countries where it is plentiful. Plywood can be disinfected by steeping it in disinfectant solutions. Galvanized iron is easy to clean and disinfect but, unlike wood, is a poor insulator. Concrete, provided it is smooth, can be cleaned and disinfected, but portable concrete installations are virtually ruled out by their weight. Glazed earthenware can be used for some accessories (troughs, or even nest boxes).

FIGURE 24 Effect of air speed (V) and temperature (T°) on health of rabbits

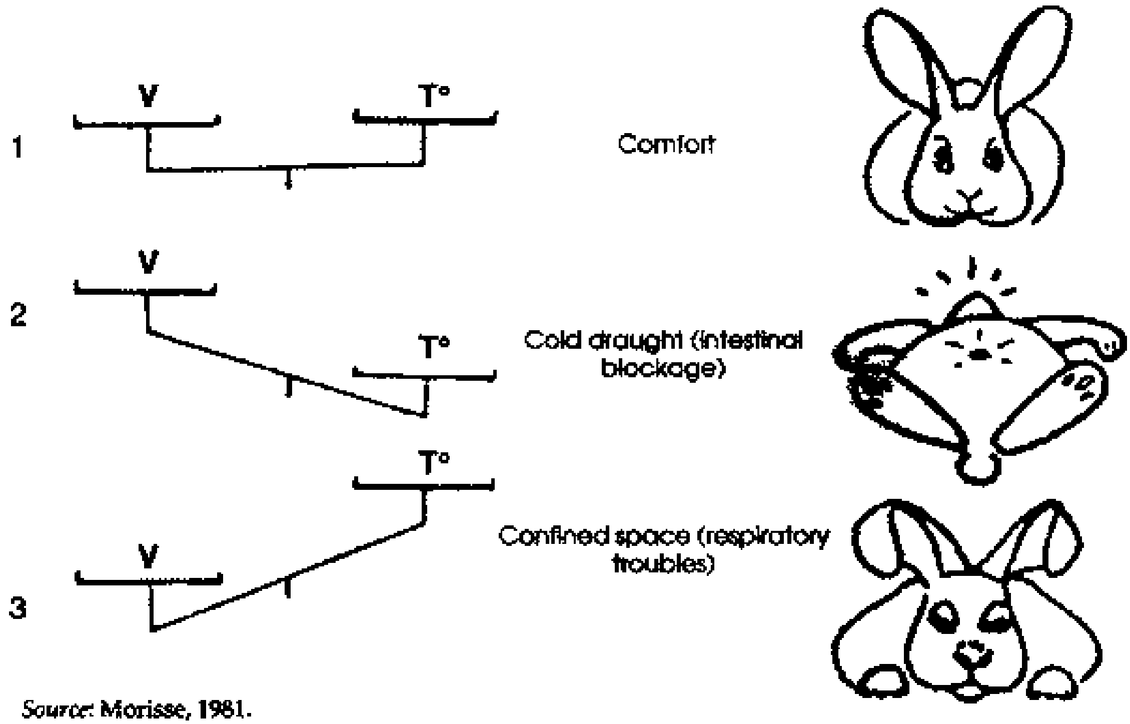
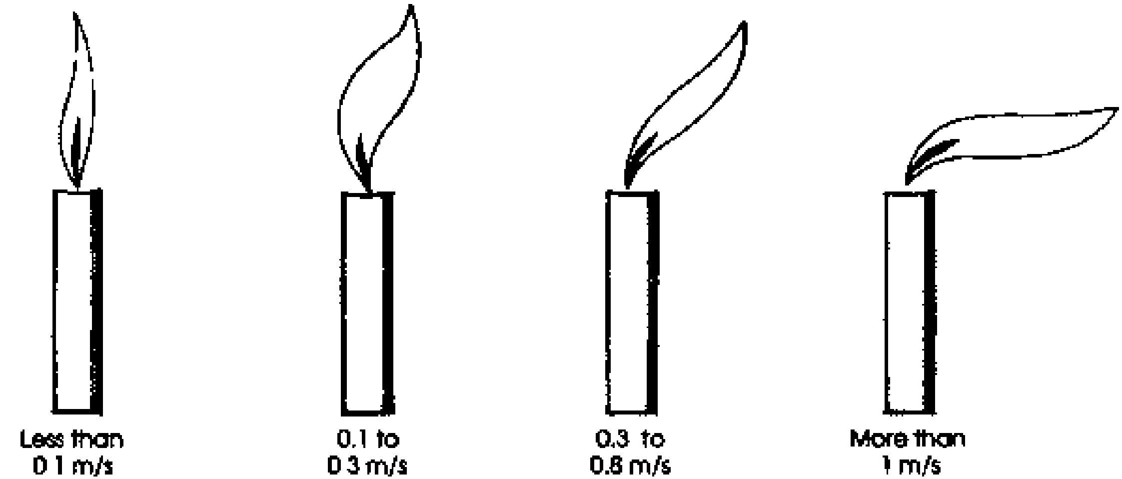


FIGURE 25 Estimating air flow with a candle flame



Source: Le Ménec, 1982

TABLE 51 Brightness of various types of lighting

Lighting	Electric power (wattage)	Luminosity (lux)
Incandescent	25	250
	40	490
	60	829
Fluorescent	20/32	750

	25/32	1140
	40/32	1880

Source: Yamani, 1992.

Caging

Cages (hutches) with straw litter. Traditional European rabbitries use straw litter. This material can be replaced by any other dry fibrous product which is not rough to the touch (soft shavings, hay, industrial cotton waste and so on). The cages are either of concrete (lasting 15 to 30 years) or wood (lasting not more than two years). Cages for breeding animals usually have at least a 60 to 70 cm × 80 to 100 cm floor space and are 50 to 60 cm high. Identical cages are often used for fattening five or six young rabbits (to 2.5 to 2.8 kg). The litter should be replaced weekly to control parasitism.

A variation called "deep litter" is used in slightly taller cages. The floor is covered with a bed (minimum thickness 15 to 20 cm) of absorbent material (turf, wood shavings) evenly covered with straw. Every six or seven weeks the whole lot, absorbing layer plus accumulated straw, has to be replaced. This system saves labour in cleaning and has the advantage of the comfort provided by the straw, but it does use a great deal of absorbent material so it is only applicable where this material is both readily available and cheap.

Cages without litter. In some regions rabbits are raised on litterless floors (hard earth or wooden planking). The hygienic conditions are nearly always deplorable (uncontrolled local humidity favouring parasitism), despite daily cleaning. This system is not recommended because of the health risks involved. The only exception is desert or subdesert regions, such as southern Tunisia, where humidity is not a problem.

The solution to the problem of changing litter has been to separate the animal from its excrement as soon as this is dropped. The rabbits are raised above the ground on a wire-mesh or slatted floor. Wire-mesh floors should be thick enough not to injure the pads of the rabbits' feet (diameter 2.4 mm, minimum 2 mm); the mesh should be wide enough to let the droppings fall through (diameter 1 to 1.3 cm, according to feed) but narrow enough to prevent the feet getting caught in the mesh.

There are good commercial meshes available in Europe. These measure, for example, 25 × 13 mm, 76 × 13 mm or 19 × 19 mm. To avoid injury to the rabbits' feet the wire is welded and then galvanized. Plastic mesh is impractical because no plastic material can withstand the animals' gnawing.

Various kinds of slats have been tried: wood, bamboo, plastic and metal, but the individual slats of the structure have to be spaced about 1.3 to 1.5 cm apart so droppings can fall through. Problems of comfort (slippery slats) and hygiene (materials which cannot be disinfected) are unfortunately very common. Wherever possible, wire mesh is preferable to slats. If slats are used instead of mesh, bamboo should be preferred to wood if possible. For heavy breeding animals, metal or inflexible plastic slats have been developed by French rabbit equipment manufacturers. While the results are satisfactory, the cost is unhappily much higher than that of wire mesh.

Only lightweight, calm animals or specially selected breeds (New Zealand White, Californian) can be raised entirely on wire-mesh floors. Producers often compromise by raising the male and female breeding animals on litter and the fattening stock on mesh floors. The breeding animals of heavy breeds can be reared on slatted floors and the young on wire mesh; but slatted floors must be cleaned more frequently.

The dimensions of breeding cages without litter used in France are shown in Table 52 (floor generally of wire mesh but sometimes of metal or plastic slats). As may be seen by comparing these figures with the dimensions given earlier for cages using litter, the mesh floor makes it possible to reduce the area of the breeding cages. At the same time the animal density per square metre (fattening animals) can be increased to 16 to 18 on a mesh floor compared with ten on litter. This is because excrement is immediately eliminated, cutting the risk of parasite contamination. Densities exceeding 16 rabbits per square metre can reduce growth in 2.3 to 2.4 kg fattening rabbits (Table 53).

Cage systems. Cage systems vary in accessibility, supervision and comfort for the animals, as well as in convenience of waste removal. Straw-litter cages will be examined first. These are either single level (cages with wooden or plywood framework) or built on several levels (concrete cages, with watertight floor beneath straw litter). The principle is generally the same. Access is by a door in the front of the cage, usually made of mesh, or hardwood latticework that must be replaced fairly often. The other walls have no openings. They must be built in such a way that the rabbits cannot gnaw them. A rabbit cannot chew on a flat wall but will slowly but surely gnaw away any protruding part of the cage. Some examples of proper wood construction are given in Figure 26. Obviously, softwoods can be gnawed more easily than hardwoods.

Litter removal can be made more efficient if the rear walls of the cages are designed to swing out, as shown in Figure 27. The cages in the illustrations were built for a colony of French Angora rabbits (which have to be reared on litter), but can be used by any rabbitry using litter, whether the cages are of concrete, as in Figure 27, or wood.

For cages without litter, mainly cages with wire-mesh floors, the structure is usually in metal or wood (the latter out of reach of the rabbits' teeth). Walls are usually entirely in wire mesh, but this is not obligatory. There are four main systems: flat-deck, Californian, inclined-slope battery and compact battery. Figure 28 illustrates the four systems. All have been used in European rational production, which means that none is perfect. However, producers prefer the flat-deck system because it has the lowest rabbit density, thus alleviating the problems which arise when many animals are reared in the same building. The main characteristics of each system are described below.

Flat-deck. In this system the cages are all on one level. They usually open at the top. They can be suspended by chains or set on feet or low walls. Floor litter drops into pits (ranging in depth from 20 cm to 1.5 m). Shallow pits are cleared daily or every two or three days and deep pits every one to three years. The advantages of the flat-deck system are:

- convenient supervision and handling of animals;
- long life for the material used;
- animal and producer comfort;
- no elaborate ventilation system required.

TABLE 52 Cage sizes for breeding animals in France (in centimetres)

	Front	Depth	Height
Doe's cage with Inner nest box	65-70	50	30
Doe's cage with outer nest box	50-60	50	30
Buck's cage	40	50	30
Cage for future breeding animal	30	50	30

Source: Fort and Martin, 1981.

TABLE 53 Influence of animal density on fattening rabbits

Number of rabbits per m^2	18.7	15.6	12.5
Live weight at 77 days *(g)*	2 150[a]	2327[b]	2384[b]
Average weight gain *(g/day)*	32.0[a]	36.1[b]	36.5[b]
Average feed intake *(g/day)*	111[a]	122[b]	122[b]
Intake index	3.35[a]	3.39[a]	3.36[a]

Note: a, b: on the same line, *two* values not having the same index letter differ significantly, to the threshold P = 0.05.

Source: Martin, 1982.

The main drawback is the low animal concentration per square metre of building, which increases the investment per animal housed despite the low-cost cages. However, flat-decks are recommended for nurseries. They could also be used for fattening, but at a higher investment cost per cage. This is usually the only type of housing in European production units now being established or enlarged.

California cage. In this system the cages are staggered, one deck higher than the other but not above it. The cages on the lower level open at the top and those on the upper level at the front (poorer access). Floor litter drops beneath the cages and is collected as in the flat-deck system. Advantages of the California system are:

- same advantages as the flat-deck with regard to ventilation;
- slight increase in animal density per square metre of building.

Drawbacks:

- access to upper cages and supervision difficult;
- frame more expensive than flat-deck.

Inclined-slope battery. The cages are placed one above the other. Waste slides down ferrocement or metal panels into troughs from which it is removed manually with scrapers or with running water. Cages obviously open at the front. Advantages of the inclined slope are:

- higher animal density;
- reasonable cost, although more expensive than flat-deck.

Drawbacks:

- no matter what material is used for the panels or how steeply they slant, waste does not drop properly and must be periodically raked down;

- high animal density demands careful ventilation;

- access to the cages, supervision and handling of the animals is more difficult.

Compact batteries. Waste can be removed by conveyor belt or vats can be installed beneath the cages and emptied by cable-operated scrapers (manual or electric).

FIGURE 26 Examples of correct and incorrect cage assembly, fostering good hygiene and resistance **(a)**

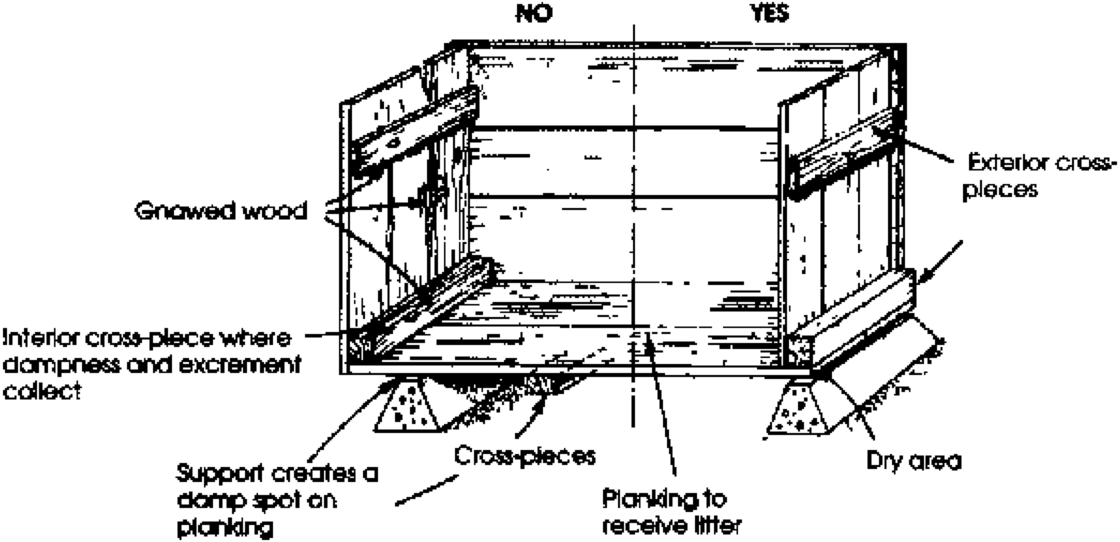


FIGURE 26 Examples of correct and incorrect cage assembly, fostering good hygiene and resistance **(b)**

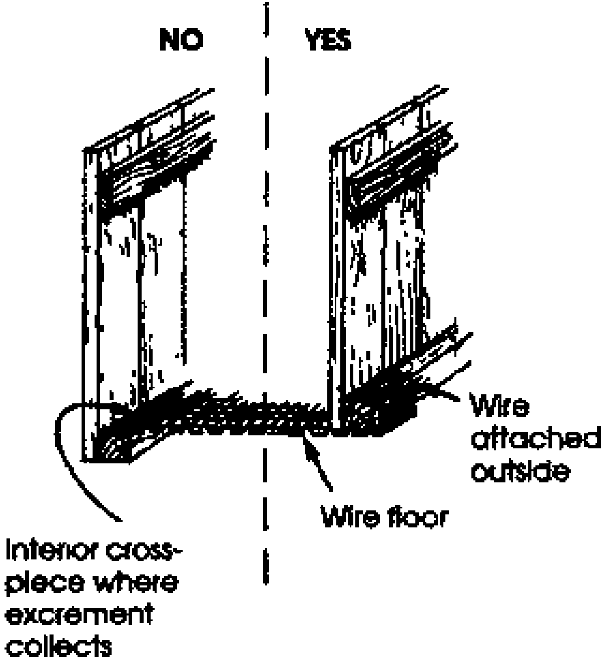
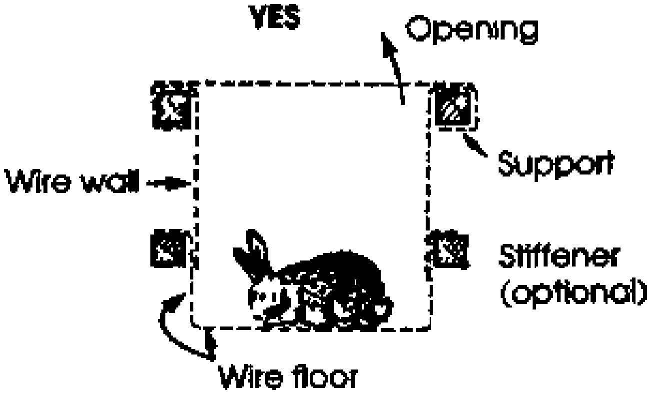


FIGURE 26 Examples of correct and incorrect cage assembly, fostering good hygiene and resistance **(c)**



Note: a = wooden cage with litter, b = wooden cage with wire floor; c = suspended wire cage.

As with the inclined-slope battery, the cages must open from the front. The advantage of this system is that the maximum density of animals reduces costs per animal housed.

Drawbacks:

- as for the inclined-slope battery regarding ventilation, access to cages, supervision and handling of animals;

- quicker wear and tear on materials;

- with automatic scraping there is the risk of breakdown and harmful gases from the scrapers;

- poor distribution of light for breeding does.

Compact batteries have virtually been abandoned for nurseries in rational European rabbitries.

Watering

A permanent dispenser of clean water is an essential item in each cage, wherever rabbits are not fed green forage alone. Using old cans or glass or earthenware pots as drinkers can create a hygiene problem. Rabbits tend to soil their water, especially if they are reared on straw litter. The drinkers should be fastened so that the rabbits cannot overturn them and so that the breeder can easily clean and refill them once or twice a day.

***FIGURE 27 Swinging rear wall in concrete hutch for waste removal* (a)**

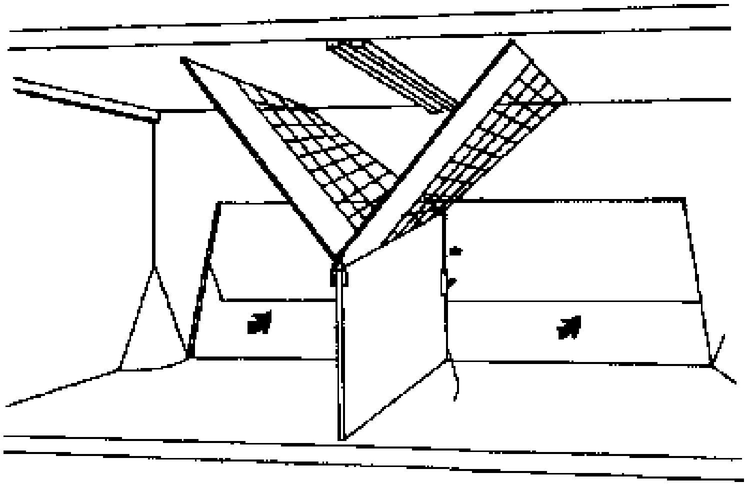
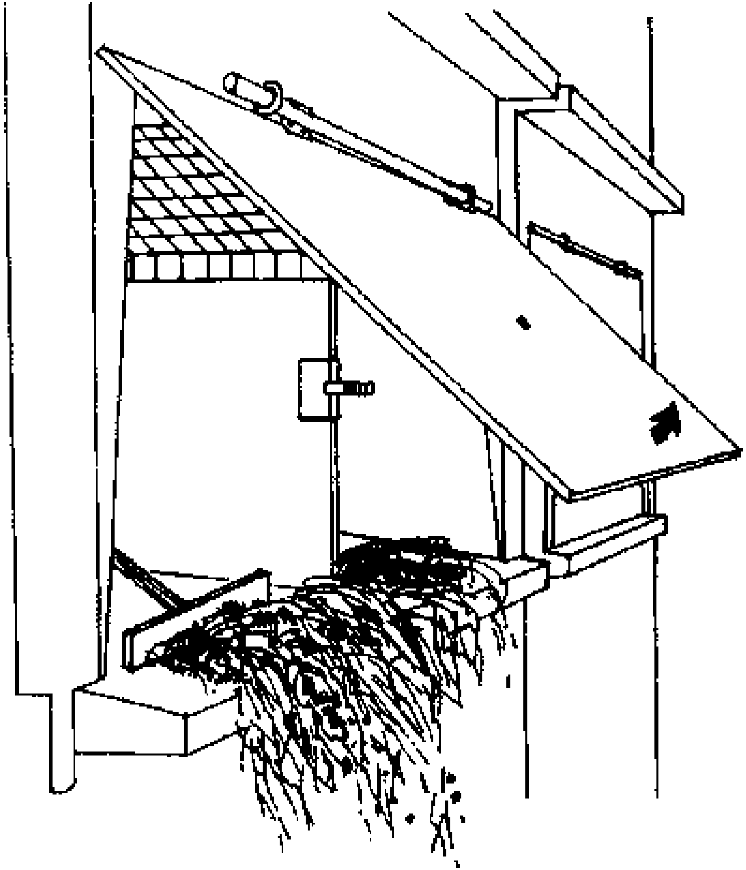


FIGURE 27 Swinging rear wall in concrete hutch for waste removal **(b)**



Note: a = front view (note forage rack, here shared by two cages); b = rear view.

Source: Thébault, Rougeot and Bonnet, 1981.

FIGURE 28 Four systems for using wire cages **(a)**

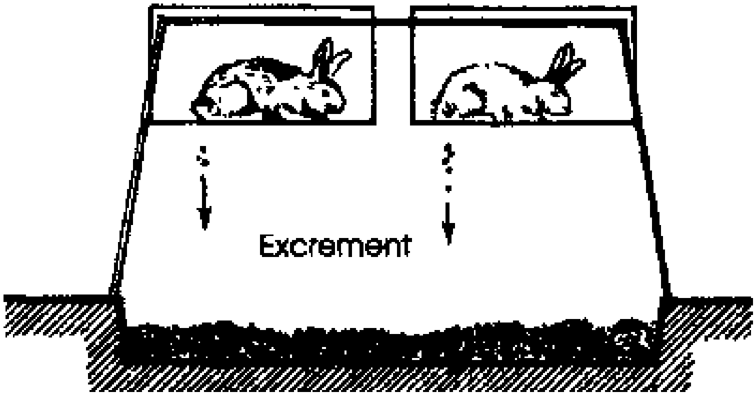


FIGURE 28 Four systems for using wire cages **(b)**

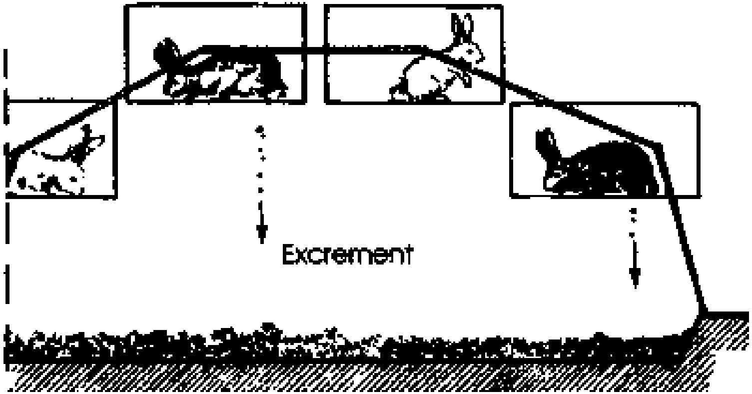


FIGURE 28 Four systems for using wire cages **(c)**

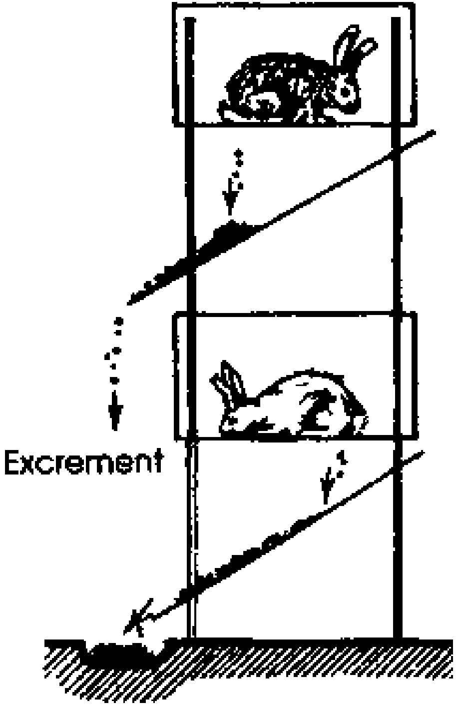
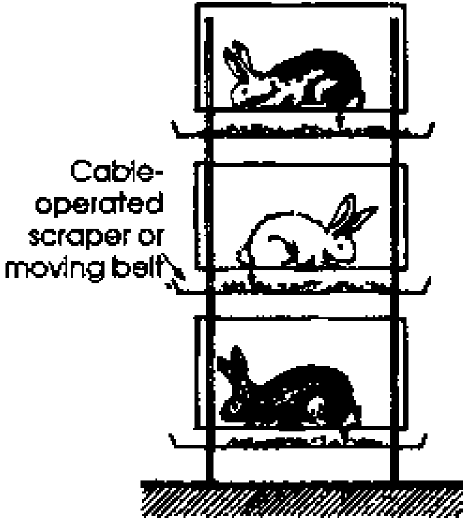


FIGURE 28 Four systems for using wire cages **(d)**

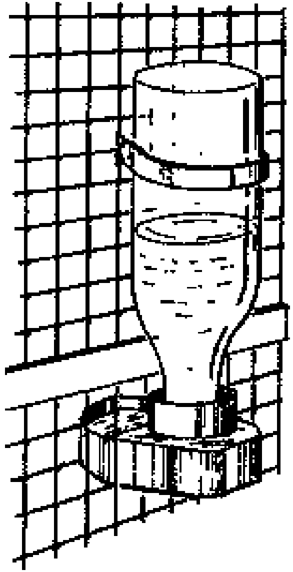


Note: a = flat-deck; b = Californian; c = inclined-slope battery; d = compact battery.

One possible improvement is an inverted water-bottle drinker. A bottle is inverted over a small trough (Figure 29), which is small enough to restrict pollution. The bottle is big so that it needs to be refilled less often and the breeder can see at a glance whether the animals' water intake is normal.

The best solution is an automatic drinker in every cage (Figure 30). The open drinker guarantees that the rabbits will be watered but it is expensive and there is a high risk of water pollution. A nipple drinker requires some learning on the part of the rabbits and wastes water. Even if there is no leak, the rabbits do not drink all the water that drips out. This can then wet litter or waste. The cost, however, is usually half that of an automatic open drinker. Above all, it ensures that the rabbits will always have clean water. A nipple drinker is the only kind that can be used if the rabbits are fed meal.

FIGURE 29 Inverted water-bottle drinker



Automatic drinkers are fed by water from a low-pressure tank 50 to 150 cm above cage level. This tank can be used to administer medicine with the water. It is usually filled either by water under pressure (automatic watering) or manually (semi-automatic watering). The tank must be in the shade so that the water will not heat, which would be bad for the rabbits. Further solutions are seen in Figure 31.

Feed troughs and racks

Cages should be fitted with troughs (feed hoppers for grain or pellets, small troughs for feed mashes) or forage racks, or both, depending on how the rabbits are to be fed. Troughs must be easy to clean and disinfect, so they should be detachable.

Figure 32 shows a hopper for grain or pelleted feed. Troughs and racks should be easy to fill from outside the cage without having to open the access door, but the feed must be protected from bad weather and predators. The racks should hold at least one day's ration, the hoppers enough for two or three days, and the mash troughs a single ration.

The bars of the rack should be strong enough to withstand the rabbits' teeth and keep out the young rabbits, who like to lie on the forage but soil it. The feed hopper should also have a trap to keep the young out. The width between partitions in the feed box should be about 7 to 8 cm for medium breeds. The bars of the racks can be more closely spaced (1 to 2 cm) to prevent waste.

The nest box

The nest box should be considered one of the most important items of equipment in rabbit production. It directly affects the viability of the young in the preweaning stage, which is the high-risk mortality period (15 to 40 percent of liveborn rabbits). The job of the nest box is to reproduce conditions in the burrow of a wild doe and protect the young against attacks from the outside environment so that they can get through the first few difficult days of life in optimal comfort. To do this the nest box must:

- allow the doe to kindle and nurse her young in comfort;
- keep the young in a healthy, clean environment;
- prevent dampness from the animals' urine;
- keep the young together in cold weather and help them maintain a constant temperature close to 30° to 35°C in the middle of the nest;
- in hot weather, allow the doe to scatter the nest so that the young can adapt to the temperature;
- keep the young from leaving the nest too early and make it

easy for them to get back if they do get out;

- allow the producer to monitor the litter, remove any dead animals, introduce baby rabbits to be fostered and change bedding material easily, without disturbing the doe and the young.

FIGURE 30 Automatic drinkers **(Open drinker)**

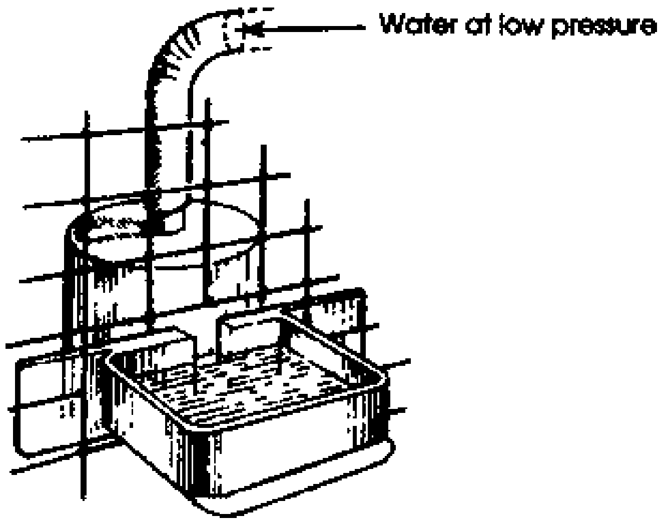


***FIGURE 30 Automatic drinkers* (Nipple drinker)**

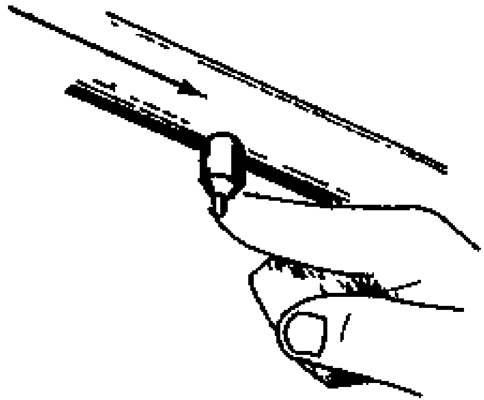


FIGURE 31 Drinker made from a nipple in plastic bottle (a)

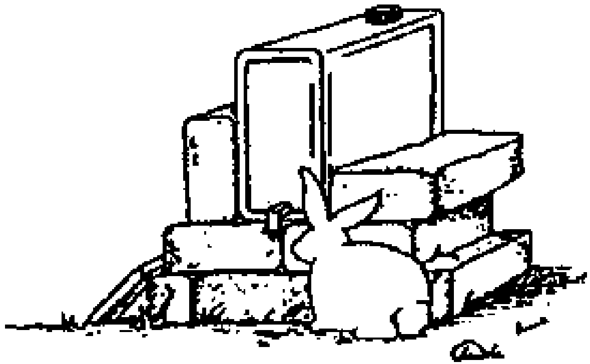
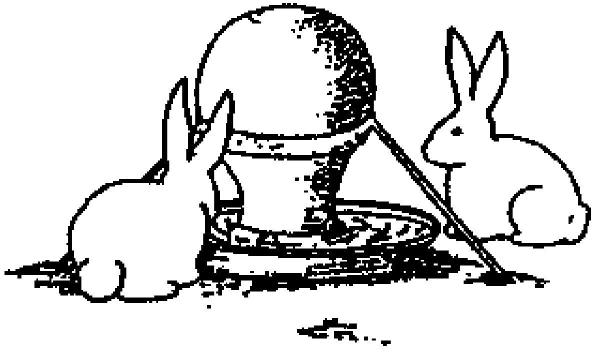


FIGURE 31 Clay drinker used as inverted water bottle (b)



Source: Finzi and Amici, 1992.

FIGURE 32 Feed hopper (a)

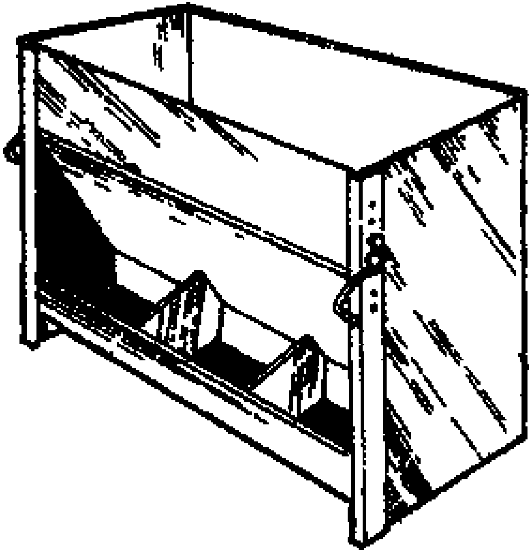
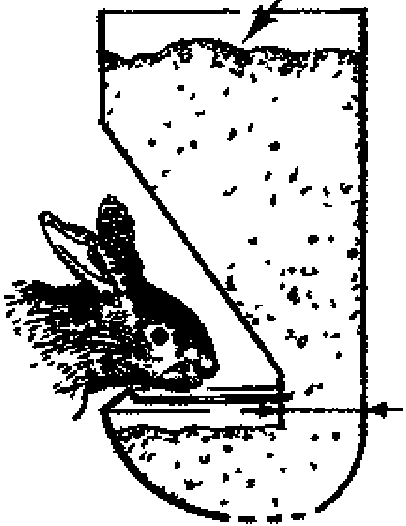


FIGURE 32 Feed hopper (b)



The nest box is strongly advised for rabbitries using straw litter; it is essential in modern production. The box most recommended to meet these requirements, especially the doe's comfort when kindling and nursing, is a rectangular paralleled pipe at least 50 × 25 × 25 cm. If there is a dividing panel to keep the young together, at least 30 × 30 cm must be left on that side so that the mother can nurse them in comfort (Figure 33).

The nest box should be made from materials that are impossible to gnaw, easy to disinfect, insulating and resistant to moisture. In a well-heated rabbitry or a warm climate, galvanized iron can be used if some other material such as plywood, wood or plastic is used for the bottom. Untreated wood, fibreboard, plywood or plastic are frequently used in Europe. They insulate better than metals, but except for plastic are not always easy to disinfect.

To comply with the habits of the doe and her young, and to make the breeder's work easier, the box should have the following features:

- the bottom should be hollowed so that the young can huddle together when the temperature drops, but it should also favour their dispersion when the temperature rises;

- the bottom should be non-skid, to prevent dislocation of the young bones ("swimming");

- access for the doe should be opposite the section holding the young so that she will not crush them when entering the nest box suddenly;

- the access hole for the dam should be fairly narrow, square or round, and about 15 cm across;

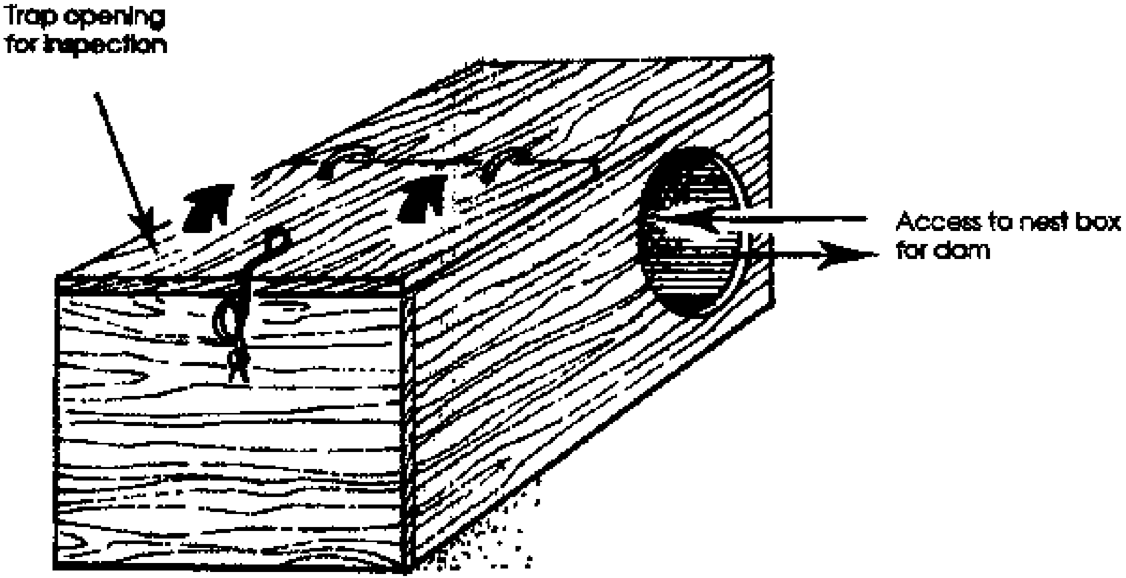
- the bottom of the box should be designed to allow urine to run off. It can be perforated or a space 1 to 1.5 cm wide can be left between the floor and the sides of the box. Another alternative is straw sandwiched between two layers of mesh;

- the bottom should be detachable so that the whole interior of the box can be cleaned;

- the top should have a trapdoor so that the breeder can easily observe and check the rabbits;

- there should be a sufficiently high ledge, level with the doe's access hole, to keep the young from leaving the box too early (before day 15). An even better solution is to install the box below the level of the cage floors so that the babies can get back easily.

FIGURE 33 Design for a nest box



Note: In hot climates the top of the box can be made of wire mesh.

The doe needs materials in addition to her own fur to make a good nest. Clean straw or soft, untreated wood chips are suitable and dried grasses can be used. Cellulose cottonwool must never be used.

The nest box can be placed inside or outside the cage. If it is outside it can be fastened to the side of the cage or preferably to the front, to make inspection easier.

Buildings

In temperate climates

In countries with temperate or cool climates, rabbits are reared in buildings that are more or less closed in order to ensure year-round production. Traditional rabbit production in Europe and North America used to be outdoors in hutches and the animals stopped breeding from the end of summer until early spring. More regular or even nonstop production has been made possible by putting the cages indoors.

Temperature and lighting can be controlled to suit the animals. Now the use of wire-mesh cages makes the rabbits more susceptible to the temperature and air flow in their environment and these cannot be controlled fully except inside a building. Even so, if the rabbits are reared in semi-open, fairly unprotected environments, as is increasingly the case for fattening rabbits in Europe, the temperature and ventilation standards in Table 50 are no longer applicable. Animals raised outside are more tolerant of weather variations than indoor rabbits.

In Europe, breeding rabbits are usually reared in floor-level wire-mesh cages, and European rabbits are thus increasingly reared inside closed buildings, with controlled ventilation, artificial lighting, winter heating and possibly summer cooling. Such solutions are costly and the producer needs substantial initial capital to house all his or her animals.

In France, for example, the total outlay (building, caging, other equipment) is figured in terms of the "mother-cage". This reference unit corresponds to the total investment necessary for housing does, bucks, fattening young and future breeders, divided by the number of does. In France the outlay per mother-cage corresponds to the value of the young rabbits produced by the mother-cage in about 12 to 18 months.

Technically speaking, the buildings are like those used for battery chickens, with similar insulation, heating, ventilation and lighting. The standards for rabbit production, described at the beginning of this chapter, are, of course, different, but for the rest the rabbit breeder can make convenient use of descriptions of buildings designed for chickens. The many instances of old stables, barns and similar buildings being converted for rabbitries is worth mentioning. Some work is usually needed: sometimes insulation, nearly always ventilation, even for flat-deck systems. Unlike compact batteries, the flat-deck system does not need a very long building, and can therefore usually be installed in any existing construction.

In constant hot climates

In countries where the climate is hot but fairly constant (mean minima and maxima between 20° and 30°C) closed buildings are not really necessary. All that is needed is to protect the rabbits against the weather. If the cages are of wood or concrete (solid walls) it may be enough to roof each hutch, as shown in Figure 34. A roof should keep off rain and also heat from direct sunlight. The hutches can also be placed under trees big enough to shade them all day long. A roof should overhang enough to keep water out on rainy, windy days. The hutches should face away from the prevailing winds.

Wire-mesh cages can be grouped under a common insulating roof.

This system, illustrated in Figure 35, was first tried in California. It is satisfactory provided the roofs overhang far enough at the sides to protect the animals properly. A hedge or fence around the roof structure is useful in protecting the rabbits from strong winds, and from predators.

In variable hot climates

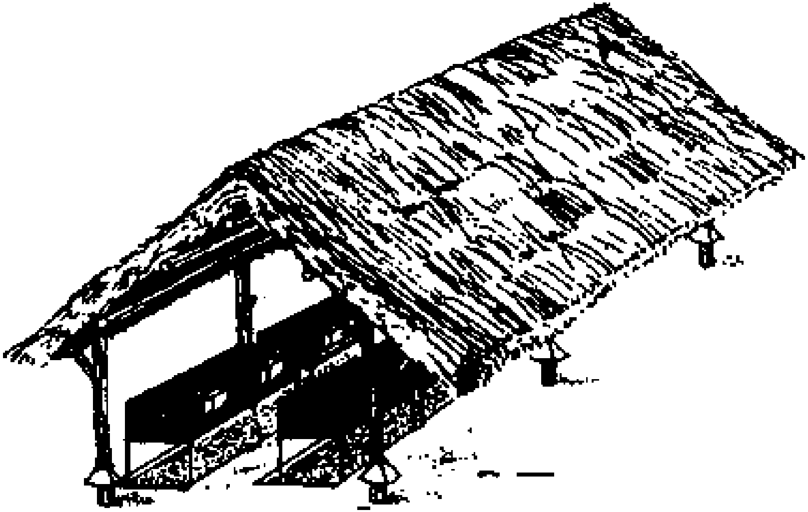
In such climates the rabbits must be reared either on litter in hutches out in the open, or in cages placed inside a building which will serve as a buffer against the heat. Very satisfactory results have been obtained in Burkina Faso with buildings constructed with local palmyra *(Borassus aethiopium),* and a straw roof. The temperature in a building like this is more constant than in a more costly one made with concrete perpend.

At the Irapuato National Rabbit Centre in Mexico, solid buildings are generally left open in the front during the day and at night the shutters are closed to offset the drop in outside temperature. A daily temperature range of 20°C is common in the region. These shutters also make it possible to ventilate the interior during the daytime; they can be opened to suit the wind direction and regulated to respect the air-flow standards mentioned at the start of this chapter.

In some dry tropical regions of Africa where wood is scarce, producers have made satisfactory housing by building small round huts of unbaked earth bricks covered with straw, used for both cage and housing. Litter changing is often quite a problem with this sort of construction, however. The floor should slope slightly and be off the ground. Parasitism can be partially controlled by demolishing the hut every year and rebuilding it a few metres away. Such housing is thus only suitable for backyard rabbitries in which labour is not a problem.

FIGURE 34 Outdoor wooden cage

FIGURE 35 Wire-mesh cages under a common roof



Predators

The problem of predators differs greatly from region to region. The first step is to build cages sturdy enough to withstand the rabbits themselves and the numerous dogs and cats found in many villages. The rabbitry should be fenced to keep out children and large predators such as dogs. This also helps provide the quiet surroundings that rabbits require. According to needs, the building or complex of cages making up the rabbitry should be fenced with wire netting, a living thorn hedge or sturdy pickets.

Rats, mice and other rodents are also dangerous predators as they attack the young and carry diseases. Any rats in the rabbitry should first be exterminated, then the legs of the cages and the poles holding up the roof can be fitted with tin plates or cones at a height that will prevent rats from climbing them. Wire-mesh or concrete cages are more effective in keeping out rats than are wooden ones.

These pests can sometimes get into the feed racks or hoppers. Where such a risk exists the openings of these accessories have to be protected too, because a mother rabbit does not usually guard her young as a dog or even a mother rat would do. Snake control, in countries where this is a problem, is a far more difficult matter. Breeders get used to paying a certain toll to snakes. Fortunately, this is a small percentage of the rabbits.

Apart from the danger of predators, the risk of escape must also be considered. If the cages and buildings are not properly closed the rabbits can get out: either during handling operations or if the rabbitry is attacked by dogs or other large animals. A well-made outer fence usually ensures that the escaped rabbits can be recaptured quickly. If they do get away, they may well be irremediably lost.

There is no risk that escaped domestic rabbits will adapt to living wild and multiply, as they did in Australia and New Zealand. In almost every other country, escaped domestic rabbits have been unable to adapt to the wild. There are numerous predators of animals the size of rabbits (dog and cat families, birds of prey), which soon destroy them. The only risk is on certain islands where potential predators do not already exist, as was the case in Australia in the last century.

Unconventional housing

The usual techniques for cages and buildings known to give reliable results in all climates have been described so far. This does not rule out other practical solutions, some examples of which are given below.

Underground rabbitries

In the southern parts of Tunisia and Algeria, breeders traditionally rear rabbits in a dry "well" 1.5 to 2 m deep (Finzi, Tani and Scappini, 1988). Breeders first dig the well and then lower the rabbits who will breed a colony, building burrows at the bottom of the well. These are used by does as nests, reflecting wild rabbit burrows. The breeder simply throws down fodder, which can occasion significant waste. In more elaborate rabbitries, the breeder digs a sloping tunnel from the bottom up to ground level where it emerges into a small pen. The feed is set in the pen and the rabbits come for it at will (usually at night). A trapdoor in a corner of the pen allows the rabbits to be caught. Of course this system can only work in countries where it hardly ever rains and the ground remains dry down to 1.5 to 2 m. Another drawback is uncontrolled breeding and the breeder may easily maintain totally unproductive rabbits for long periods. Predator control is virtually impossible as well, particularly for rats.

Finzi (1992) describes another underground pen for group rearing, the result of field observations and experiments, shown in Figure 36. Note the simple predator control and rabbit shelter concepts.

Cage rearing

A system of cages using broad cement channels (0.8 to 1 m wide) laid horizontally has been described in Spain by Contera (1991). The rabbits live on a wire-mesh floor slightly narrower than the channels, and the droppings fall into the channel. The cage/shelters are conventionally equipped. In the hottest hours of summer, systematically sprinkling the outer walls of the channels cools the temperature compared with the outside, the water evaporating through the fairly porous cement of the channels.

Another heatproof device was described by De Lazzer and Finzi (1992): a system of dual-zone cages. Outside is the conventional wire-mesh cage with the feed racks and inside an "area" of equal volume buried beneath a layer of thick earth but accessible to the breeder through a trap, with the two connected by a 20 cm fibrocement tube (Figure 37). These authors have reconstituted a living area for the fattening or nursery rabbit(s) in the cage that resembles the living space of wild rabbits. During the hot hours of the day, or when there is a disturbance (or to kindle), the rabbits stay underground. When hungry or thirsty, they move into the wire-mesh cage. Experience has shown that the animals always use the outside as a latrine area. The technical results obtained by these authors in one year indicate a productivity wholly comparable with conventional closed rearing in cages, but at lower cost. No information is available on the labour required to build the system.

FIGURE 36 Rational enclosure for rabbitries

Uses for waste

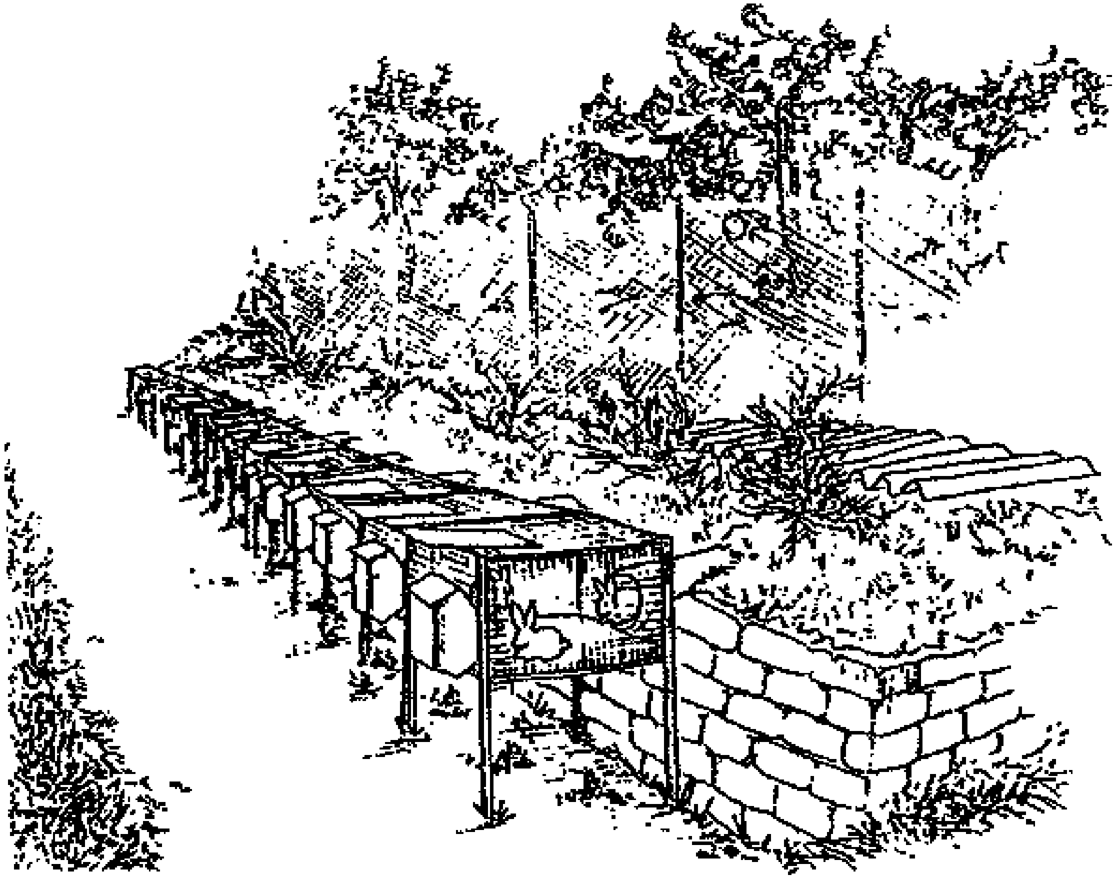
In every type of rabbit production unit the producer has to remove the excrement and waste from the rabbitry (straw litter and droppings which pile up under cages). These can be put to good use on the farm. The amounts and composition of waste vary according to housing and feeding conditions.

Rabbits eating balanced concentrate feeds and raised on mesh floors produce about 25 to 400 g of faeces and 0.5 to 0.8 litre of urine per mother-cage a day, depending on production intensivity. This waste is much richer in nutrients than ordinary farm manure (Table 54). In fact, farm manure contains only 0.4 to 0.6 percent of each of the main fertilizer components: N, P_2O_5 and K_2O.

The composition of the waste varies with the type of rabbit (Table 55). A comparison of the figures in Tables 54 and 55 shows a greater risk for nitrogen and phosphorus losses during storage than for other elements.

The average composition of the manure of rabbits reared on litter depends partly on the kind of feed but mostly on the kind and amount of litter used. If well preserved, the waste collected weekly will contain the nutrients in the faeces, part of those in the urine and those in the litter. Fertilizer "production" is therefore at least equal to that in a rabbitry not using litter.

FIGURE 37 Two-zone cage: wire-mesh (at left) and underground (at right). The breeder has access through the corrugated top laid over the underground area



Source: De Lazzer and Finzi, 1992.

TABLE 54 Average composition of excrement collected under wire-mesh cages of rabbits receiving balanced concentrates (percentage)

Breakdown of crude product	From Varenne, Rivé and Veigneau, 1963	From Franchet, 1979
Dry matter	40-50	24-28
Total minerals	14-18	5-11
Nitrogen	0.8-2.0	0.7-1.0
P_2O_5	1-3.7	0.9-1.8
K_2O	0.2-1.3	0.5-1.0
CaO	0.9-3.4	0.4-2.0
pH	7.2-9.7	8.1-8.8

Source: Varenne, Rivé and Veigneau, 1963; Franchet, 1979.

TABLE 55 Quantities and composition of excrement produced by different categories of rabbit

Origin	Weight produced per day (g)	Content of fresh product (%)			
		N	P_2O_5	K_2O	CaO
Faeces					
Fattening young	40-50	1.5-1.7	2.5	0.5	0.4-1.5
Nursing doe	150-200	1.2-1.5	5-7	1-1.5	2-3
Resting adult	70-80	1.2-1.5	2-4	0.5	0.4-1.5
Urine					
Fattening young	80-110	1-1.3	0.05	0.8-1.2	0.4-0.6
Nursing doe	250-300	1-1.3	0.02	0.7-0.8	0.15
Resting adult	100	1-1.3	0.08	0.9-1.2	0.6-0.7

Source: Lebas, 1977.

Chapter 7 RABBITRY MANAGEMENT

Questions of management are discussed in various parts of this book. This chapter brings these different aspects together. The technical and economic criteria presented apply primarily to rational rabbitries of a certain size (at least 50 does). The rules of technical management are the same for smaller units, but the economic variables are different. The objective of small-scale units is not to make the greatest possible profit, but to achieve satisfactory productivity with a low-input system using local resources and family labour.

The production cycle

As ovulation in does is induced by mating and the females are generally kept in different cages from the males, it is the breeder who determines the reproduction rate of the unit. These rates vary from one or two litters a year under the most extensive management to eight to ten litters in an intensive management system. In rational European rabbitries does are remated either immediately after kindling (intensive system) or about ten days later (semi-intensive). European backyard rabbitries use a more extensive system, presenting the doe to the buck one or two months after kindling. Young does are first presented for mating at four to seven months, depending on the breed (lighter breeds are usually more precocious) and, especially, on the diet.

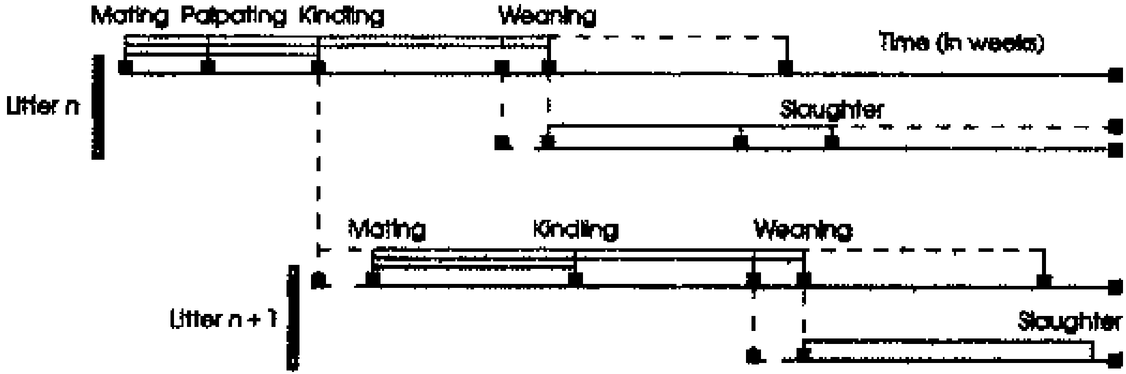
In the semi-intensive system illustrated in Figure 38, the does are first presented to the buck at four and a half months. They are then mated 10 to 12 days after the birth of each litter. Weaning takes place at 30 to 35, or even 37 to 38 days. Many European breeders (France, Italy, Spain) used to practise the intensive system: mating does within 48 hours of kindling and weaning the young at 26 to 28 days. This, however, requires very good feeding and a producer with a fairly high level of expertise and was gradually abandoned during the 1980s.

Extensive systems are characterized by a long delay between kindling and mating, and perhaps even until weaning. For example, the young may be weaned at 56 days and the doe mated after weaning. This system is still practised in France in farm rabbitries, where breeding does are fed fodder and grain.

At weaning the young are separated from the doe. The duration of fattening varies, depending on the carcass weight required and the growth rate possible in the feeding and production conditions of the rabbitry.

In intensive European production, where weaning takes place at one month, the fattening period is seven weeks. The rabbits weigh 2.3 to 2.4 kg (live weight) when they are ready for the market. Some African breeding units where weaning takes place at two months are reported to need a four-month fattening period, because balanced feeds are not available. European and North American countries which market rabbits at live weights of 1.7 to 1.8 kg use a different system. The young are not weaned. They are left with their doe up to the age of two months, when they are sold. The mother is remated three weeks before that. This system can produce five or six litters a year. In Spain, however, at a highly comparable sales weight of 1.8 to 2 kg live weight, rabbits are weaned at about one month, then fattened for only one month more. These breeders are actually using the semi-intensive reproduction rate to obtain a great many kindlings and hence more rabbits per doe each year.

FIGURE 38 Production cycle of the domestic rabbit



Reproduction

Mating. Servicing is always done in the buck's cage. The breeder checks the doe's health at this time to make sure she has no respiratory disorder, sore hocks, etc., or that she is not too thin. A red vulva is a promising but not infallible sign (80 to 90 percent chance of mating success). A buck can fertilize a doe with a white vulva, but the success rate is only 10 to 20 percent. When the doe has accepted mounting and the buck has serviced her the breeder removes the doe and puts her back in her own cage. Altogether this should not take more than five minutes.

While the doe is being handled the producer can carry out any treatment necessary - anti-mange, for example. If the doe refuses to mate, the breeder can try to present her to another buck, as a last resort leaving her for 24 hours in the buck's cage but then cannot be sure that mating has taken place. It is better to mate the animals in the morning or evening, to avoid the hottest hours of the day. Some breeders in France practise double mating. This means that the doe is mated twice in succession at intervals of 10 to 15 minutes, either by the same male or by two different males. A similar technique is to leave the female in the male's cage for 15 to 20 minutes after mating has first taken place. These techniques allow a slight increase in the percentage of pregnant does (4 to 6 percent, roughly). The drawback, however, is that it considerably increases the number of matings per male and in this system no male can be mated to more than two females each week without jeopardizing the outcome through over exploitation of the buck.

In intensive breeding one buck can serve seven or eight does. In the extensive system one buck can serve 10 to 15 does. The buck, however, should not be used more than three or four days a week, and not more than two or three times a day, which means no more than six ejaculations per week. So even if there are only, say, ten does in the unit, there should be at least two bucks so that successful mating is not dependent on one buck alone. When the size of the unit permits (at least 50 does), one or two reserve bucks are kept. If a balanced pelleted feed is used the bucks should be fed from 120 to 180 g per day, depending on their weight.

The first mating of medium-size, properly fed does takes place around four months. Bucks are first mated at about five months. If production conditions are not optimum the first mating will be delayed until the animals reach 80 percent of their adult weight. There is no advantage in delaying it further. The breeder should carefully supervise the first mating. For the first month the young buck should not be mated as often as an adult.

Determining pregnancy. The only effective way of determining pregnancy is to detect the embryos in the doe's uterus by palpating the abdomen. This operation should be carried out between 10 and 14 days after mating. It is not effective if performed earlier (before the ninth day), while after the 14th day the operation is more delicate and there is a risk of provoking abortion. The breeder must palpate the doe gently and expertly in order not to cause an abortion.

If palpation shows the doe to be empty she is presented to the buck again as soon as possible, if the breeder mates the animals every day in the week. But if the breeder practises group rearing or cycling (paced by the week), he or she will represent the doe to the buck (or use artificial insemination) two to three weeks after the non-productive mating. If the rabbits are merely raised as a group, however, with all does in the production unit at the exact same stage of reproduction (in this case only artificial insemination is used), an empty doe will simply be marked for the appropriate feeding (and perhaps housing) for her situation. She will be reinseminated only with the other does in the production unit. Presentation of the doe to the buck as a test of pregnancy is pointless, though not dangerous. Indeed, a large proportion of pregnant does accept mating and some empty does refuse. Nor is doe live weight an indication of pregnancy, because weight fluctuations depend on too many factors.

Preparations for kindling (supervision, nest box, changing bedding material, etc.) should be made for all the mated does from the 27th to the 28th day after mating if they have not been palpated, but where palpation has been practised regularly the preparations are restricted to does found to be pregnant.

A pregnant doe that is not nursing a litter will be rationed if the breeder uses pelleted feed. The daily ration for medium-size does will be about 150 g (35 to 40 g/kg live weight). If the doe is nursing a litter at the same time she will be fed ad lib.

Kindling. Kindling should take place in quiet, hygienic surroundings. The breeder's presence is not required, but the nests should be checked as soon as possible after kindling. This operation is easy and there is no risk to the young. It can be performed right after kindling, provided the mother is removed. The breeder should remove any dead animals and any foetal sacs the doe has not eaten.

A nursing doe needs considerable nutrition and from the time of parturition she should be fed ad lib. Drinking-water is very important in the days leading up to and following parturition. The doe will nurse her young once a day, usually in the early morning.

The mortality rate between birth and weaning is still high (15 to 20 percent today in European rabbitries). A mortality figure of less than

10 percent is very difficult to achieve. Therefore the nests have to be inspected daily and any dead animals removed. Strict preventive hygiene is more important than ever at this period.

Fostering. The breeder may decide it is necessary to eliminate excess newborn rabbits in a large litter, or they may be fostered to a smaller litter, if certain rules are respected:

- no more than three or four young rabbits should be given to a foster mother;

- the maximum age difference between the foster doe's litter and the fostered young should be 48 hours;

- fostering should take place within three days of kindling.

Where a production unit is big enough, and particularly where the breeder practises group rearing, systematic fostering is recommended to achieve equal litter size. The ideal size for withdrawal/fostering is average litter size at kindling (or somewhat smaller if there is a feeding problem). Where there are too many young rabbits the chances of survival are poor and, if young rabbits are to be culled, the lighter ones should be chosen.

Weaning*.* During the weaning period the young gradually give up milk for solid feed. Weaning is also the time when the breeder separates the young from the doe. The breeder may opt for one of the two following weaning methods: all rabbits in the litter are withdrawn at the same time and placed six to eight per cage in the area set aside for fattening. Alternatively, the doe may be removed from the cage and the young rabbits left, a method which reduces postweaning stress for the young rabbits but does necessitate the right production equipment. Management must be geared to group rearing. If the young rabbits are moved (still the more common system), the cages must be very clean and the litters should be kept together, if possible, for uniformity. The alternative is same-age cages (maximum age difference one week) with all rabbits put in the cage the same day. Rabbits soon establish a social hierarchy in the cage and any new introduction is a source of conflict. During the transfer operation the breeder checks the health of the young rabbits, culling any that are undersized or sick.

Weaning can take place when the rabbit's live weight tops 500 g (after approximately 26 to 30 days in rational European production). The young rabbits begin to eat solid feed at 18 to 20 days and at 30 days the doe's milk provides no more than 20 percent of the daily dry-matter intake. Practically speaking, young rabbits benefit from late weaning until the age of six weeks. Depending on the rate of reproduction chosen, weaning should take place no later than two or three days before the doe's next kindling: e.g. 28 days for postpartum fecundation to 38 to 39 days for fecundation taking place 11 days after kindling (42-day rate).

Stock reduction and renewal of breeding does. One of the apparent drawbacks of intensive reproduction is the rapid turnover of breeding stock. Monthly culling rates of 8 to 10 percent are not uncommon. In fact, where reproduction is intensive the breeder soon learns the value of each doe and can thus keep the best. The total number of rabbits produced by each doe during her working life is fairly independent of the rate of reproduction imposed by the breeder. Whatever the reproduction and the monthly stock renewal rates, to avoid having empty cages in the nursery there should be a constant reserve of does available that are ready for mating.

The breeder has several means of renewing breeding does. The most practical solution, applicable to both pure breeds and "ordinary" strains, is to select the best young from the best does. To avoid inbreeding, the bucks and even the does should be obtained from another breeder (selector). If production is intensive, the producer can buy breeding animals from a selection programme of specialized strains for cross-breeding - the system of stock renewal to follow will be advised by the supplier.

Renewal mainly takes the following two forms:

- The introduction of male or female breeding animals for direct replacement of does or bucks which have been culled or died. These are called "parental renewal stock" (the direct parents of rabbits intended for sale).

- The introduction of grandparents. Here, the parental rabbits are born within the breeding establishment, the progeny of bucks and does of special complementary lines which live and produce in the same establishment and have a reserved place in it. These grandparent rabbits are in turn replaced by rabbits direct from the selection centre, but in much smaller numbers than needed for the direct renewal of parental animals.

Whatever the genetic type of rabbits brought into the establishment for the renewal of breeding stock, they should be brought in at a fairly early age. INRA's research shows the best solution to be day-old rabbits. This method, proposed in 1987, was soon adopted by French breeders. The future breeding rabbits are immediately fostered by does with good maternal aptitude in the establishment. The young rabbits adapt much better than those introduced at the age of eight to 11 weeks, and particularly four months or older. The rabbits nurse only once in 24 hours, leaving an entire day for their transfer from the selection centre to the rabbitry. This has even been extended to 36 hours to allow the day-long and problem-free transfer of rabbits from the west coast of the United States to France.

Fattening and slaughter

During the weaning-to-slaughter growth period the rabbit should always be fed ad lib. If the breeder uses balanced concentrates, the average daily consumption will be 100 to 130 g for medium-size animals. In good conditions the rabbits will gain 30 to 40 g a day, which means an intake of 3 to 3.5 kg feed will produce a 1 kg gain in live weight. Young fattening rabbits can also be fed cereals and fodder, with or without the supplement of a suitable concentrate.

During this period mortality should be very low - only a fraction of the fattening stock - but it is often far higher. Preventive hygiene (cleaning, disinfecting) is essential in the fattening station, but the breeder is often inclined to pay less attention to this area than to the nursery.

The animals are sold alive or as carcasses. Rabbits raised in rational production systems are sold at about 70 to 90 days at weights of 2.3 to 2.5 kg for strains such as the New Zealand White and Californian. In extensive production systems with less well-balanced feeding the rabbits may be sold much later (four to six months, maximum). Fattening animals that have passed the usual age for sale can form a reserve from which the breeder can draw for home consumption or stock renewal. In farm rabbitries, the mortality risk from accidents, epidemics and so forth is still high and any delay in the regular slaughtering age for whatever reason, such as keeping the rabbits alive for gradual home consumption, can end in disaster, with the death of all the animals. The higher the mortality rate during fattening, the more the breeder will tend to shorten the length of this production phase.

If rabbits are to be kept beyond three months the bucks must either be put in individual cages or castrated, so that they can continue to be colony reared. The females may remain in groups, but will need more cage space than they did before three months. Castration is a simple operation, though it usually requires two people (see brief description in Figure 39).

Breeders may wish to slaughter their own animals. The necessary installations are relatively expensive if the proper standards of hygiene and conservation (cold storage, etc.) are to be respected. Staff who will work only a few hours per week are also needed.

Handling rabbits

Rabbits should be handled gently. They should be lifted by their ears as little as possible. Several techniques can be used to pick them up and hold them.

FIGURE 39 Castration of young male rabbit

A rabbit can always be picked up by the skin of the back (Figure 40). For animals weighing under one kilogram, one method is to pick them up and carry them by the saddle just above the hindquarters, using thumb and index finger (Figure 41). If the animals are heavier it is best to take them by the skin of the back, but if they have to be transported or shifted for more than five or ten seconds they must either be supported with the other hand (Figure 42) or be carried on the forearm with the head in the bend of the elbow (Figure 43).

If an animal struggles and the producer feels he cannot control it, it is best just to drop it so it will fall on all fours and then pick it up again correctly within two or three seconds. If the breeder keeps his hold on a struggling rabbit he risks some nasty scratches and can even break the rabbit's backbone.

Organizing and managing a rabbitry

First operation: identification

Identification can be made in two ways: by individuals and by cages.

The first method is necessary for all producers who intend to select. The second is important for the economic management of the rabbitry.

FIGURE 40 Correct way to pick up a rabbit

FIGURE 41 Holding a young rabbit head down

The animal is grasped by the back at the haunches.

Individual identification. Each animal is assigned a number. This number will appear on all documents concerning the rabbit and on the rabbit itself. There are three main ways of identifying rabbits on a lasting basis; not all are equally good:

- rings: a numbered ring is attached to the hind leg just above the hock. Risk of losing the ring is high;

- clips: numbered clips are attached to the rabbit's ears. These clips are made of metal or plastic and risk of loss is again high;

- tattooing: small holes are punched in the rabbit's ear spelling out numbers or letters and these are filled by rubbing in a special ink. A well-made tattoo lasts throughout the rabbit's lifetime. Although this method takes longer, it is the only one that is really sure. It can be done at weaning using special rabbit pincers, or on adult rabbits with sheep pincers (Figure 44).

Cage identification. The management unit of a rabbitry is the mother-cage. All the cages in the nursery section should be numbered and this is the figure that will appear on the records. This method is much easier than individual identification so it is used in rabbitries which keep records but do not breed for selection purposes.

An identification system is essential even in small rabbitries. It will form the basis of the technical records that will serve for both the organization of the work and the economic management of the rabbitry.

Technical records and organization of work

In the nursery. This unit will occupy most of the producer's attention. A daily record book is essential in almost every kind of production. In large European production units, most of this information is now computerized. The producer notes the chief operations simply and clearly:

- mating days for each doe, indicating sire (used to check buck fertility);
- outcome of palpation, where performed;
- numerical size of each litter at birth;
- numerical size of each litter at weaning.

FIGURE 42 Carrying a large rabbit, supporting its hindquarters

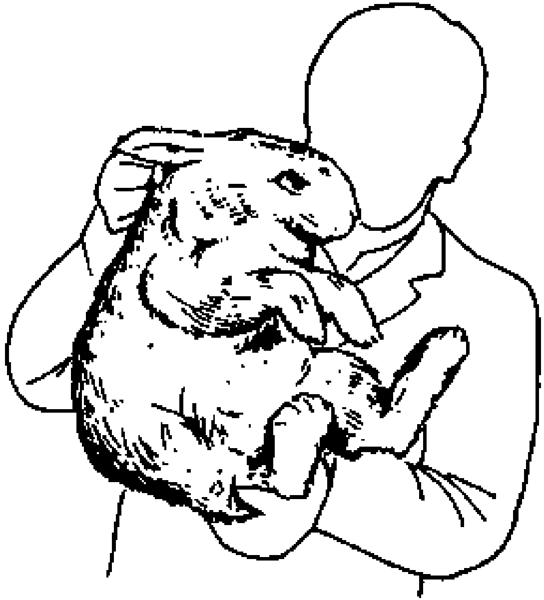


***FIGURE 43 Technique of carrying a rabbit on the forearm* (Calm animal)**

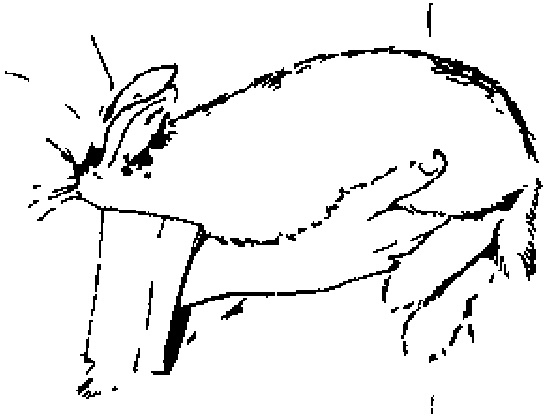


FIGURE 43 Technique of carrying a rabbit on the forearm

(Agitated animal)

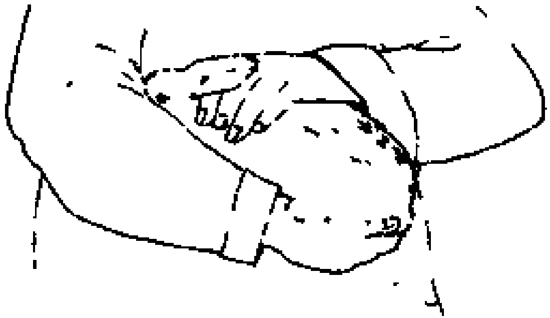
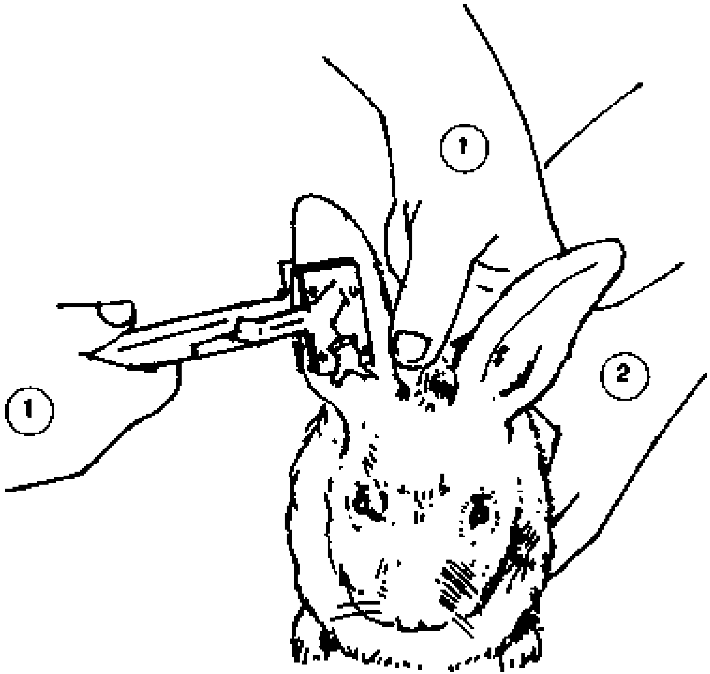


FIGURE 44 Using a clipper with movable numbers to tattoo the identification number on a rabbit's ear



Note: 1 = operator's hands, 2 = assistant's hand.

The young does selected for replacement are identified at weaning.

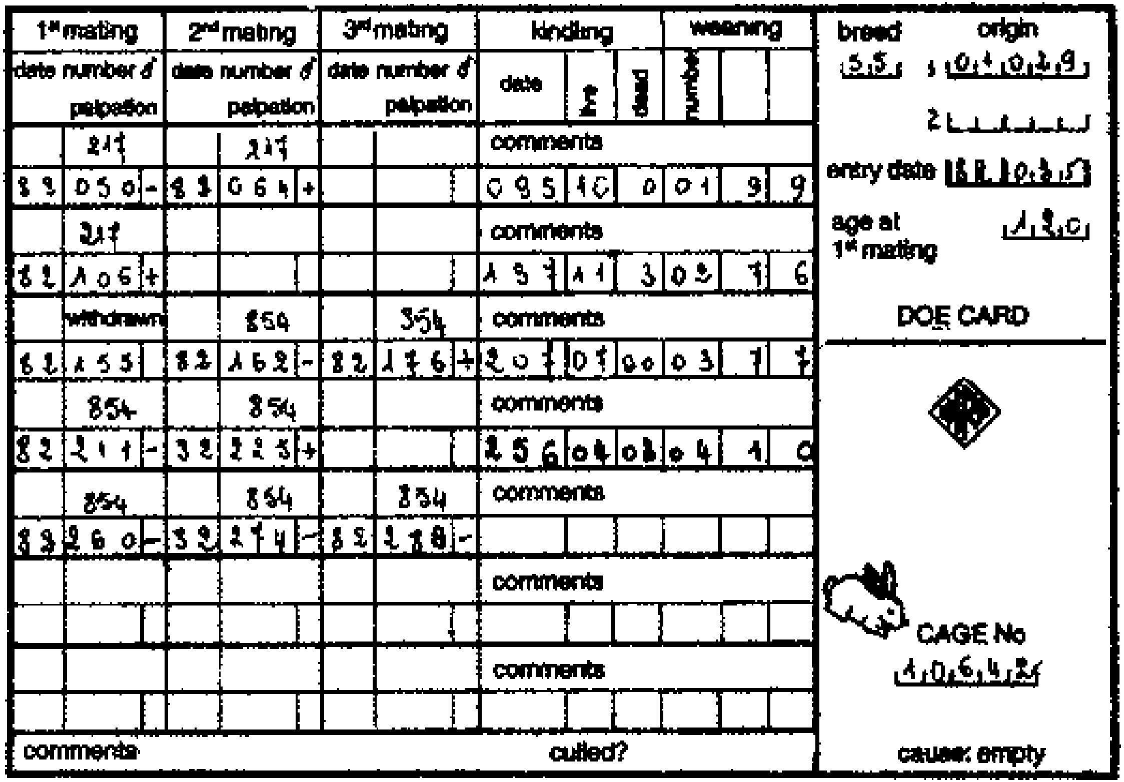
This list is far from complete. Litter weight at weaning could be added, for instance. If the producer uses balanced feeds the amounts fed in the nursery will be entered to compute the average feeding cost per weaned rabbit. This is an important item in calculating net profit. A similar entry would be equally helpful for other types of feeding, but these are far more difficult to estimate.

The record book system is often inadequate. One improvement is a doe card hooked to each cage, for calculating individual doe productivity. The example shown in Figure 45 summarizes the items of information just listed. Another useful addition is a buck card (Figure 46).

The next step is to put the data together to get an overview of the unit for efficient organization of the work. This is essential in any rabbitry with more than a few dozen does.

Planning pigeonholes (Figure 47) offer a virtually foolproof way of monitoring all events in the nursery. Assuming that does are remated and litters are weaned no later than one month after kindling, the system involves a large box with four horizontal rows of 31 compartments. Each corresponds to a day of the month. The first row is for matings, the second for pregnancy checks (palpation), the third for births and the last for weanings. If weaning takes place between one and two months, which is common in extensive production, there will be two rows for weaning, for even months and odd months.

FIGURE 45 Example of a doe card



Every morning the producer sees in the work book what operations are to be carried out. As each is completed, the card of the doe concerned is moved into the pigeonhole corresponding to the next operation and the day for which it is scheduled.

In a rabbitry where mating takes place ten days after kindling and rabbits are weaned at 35 days, the doe record could be as follows: suppose the doe is mated on the third day of an odd month. Her card is then placed in the palpation row. This operation is performed on the 16th of the same month (+13 days). If the result is positive, the doe card is placed in the kindling row under the second day of the following month (+15 days). If it is negative, her card will go back to the mating row. After kindling the doe card returns to the mating row under the 12th day of the same month (+10 days). At the same time, a card with the doe's individual and cage numbers will be placed in the weaning row, in space 7 of the second, odd month (+35 days).

There are other planning systems. The important thing is to use one system consistently. Computerized individual performance records can combine these parameters and list the daily operations to follow in line with the management model adopted by each breeder, listing the history of each breeding animal.

Scheduling several matings, a few palpations and the weaning of several litters all for the same day adds up to a lot of wasted time.

Using a weekly work plan one person working eight hours a day can manage 250 to 300 does. Table 56 is an example of such a work plan. Scheduled matings (Thursdays and especially Fridays) mean other activities can be grouped (weaning on Tuesdays, palpation on Wednesdays).

FIGURE 46 Example of a buck card

Date M	No. ♀	P	NL	Date M	No. ♀	P	NL	Date M	No. ♀	P	NL	
												No. of male
												______
												No. of cage
												______
												Breed
												______
												Date of birth
												______
												Weight at 1st mating ______
												Age at 1st mating ______
NOTES:												

Note: M = mating, P = outcome of palpation, NL = number of rabbits born live.

Some activities such as nest supervision and feeding have to be carried out every day.

With this method batches of litters at weaning are close to the same age. It also sets the time for activities the producer always tends to postpone, such as recording data and carrying out preventive hygiene measures.

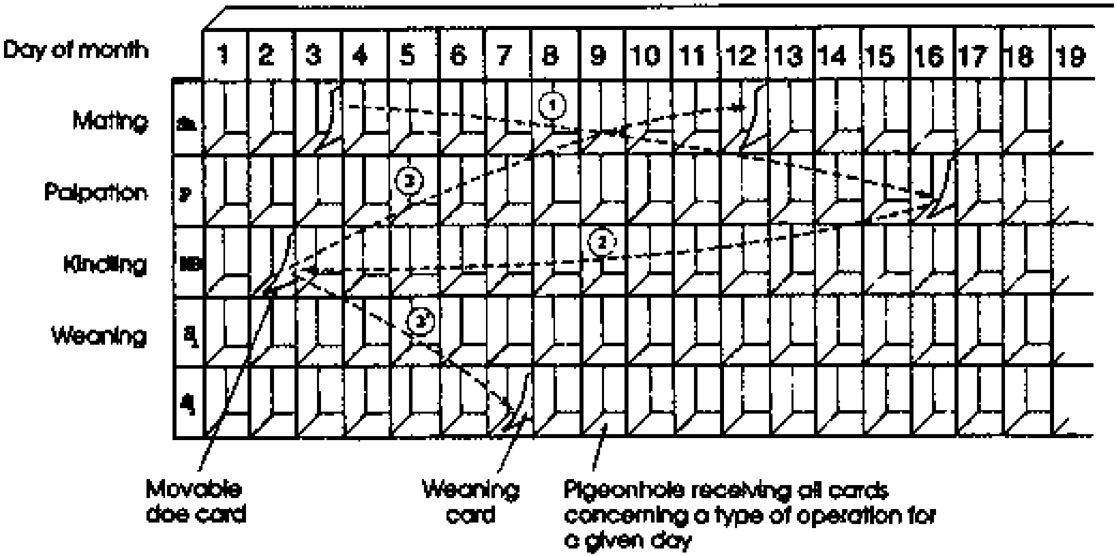
This weekly management plan, used for nearly 30 years, has expanded into age-group rearing or cycling as described above. At first all rabbits of the same age were grouped in the same part of the rabbitry (hence the term age group). Next, breeders kept same-age rabbits only in the same rearing unit. Each unit was cleaned and disinfected after the rabbits were sold or put in a newly cleaned unit. This means breeding does move regularly from one unit to another at each weaning (hence the term cycling).

Age-group rearing quickly led to rabbit production units organized into just three age groups at intervals of two weeks or two age groups at intervals of three weeks, with a semi-intensive "42-day" rate of reproduction in both instances, and fecundation by natural mating or artificial insemination. In the last two or three years, some Italian and French breeders have been working with a single age group: all does in the establishment are fecundated on the same day by artificial insemination only once every 42 days.

These different management techniques have basically evolved to reduce the amount of labour per rabbit, even though productivity per female is not as high as is theoretically possible.

Fattening records. Here again the daily record book is essential. It will list the first and last fattening days (sale or slaughter) of the animals in each cage, any mortality and the apparent causes. Live weight when sold and the number of animals marketed weekly could also be added. In large-scale operations, production checks will be done by batches (a batch is a group of rabbits weaned the same week). The batch will be the core reference point of all technical data.

FIGURE 47 Diagram of planning pigeonholes



Note: See text for explanation of card movement.

If the breeder uses balanced concentrates he or she will record the amount of feed eaten by fattening rabbits. Feed conversion efficiency (the amount of feed needed to produce a weight gain of 1 kg) is a sound economic criterion. If the producer wants to breed stock for selection purposes a litter card is used listing the weaning weight and date, the weight and date at sale or slaughter and the individual identification number of each rabbit.

Working hours. In a rational production structure under European production conditions, some 12 to 20 working hours per week per 100 does that are actually producing is the rule. Same-age rearing in a well-organized establishment can even reduce this to under ten hours. Indicatively, listed below are average working times per week in 1991 in a group of 18 rabbitries in southeastern France, each for 100 producing does and their progeny (GELRA, 1991).

• Mating + palpation	2h 28 min
• Checking nests + fostering + weaning	2 h 40 min
• Feeding	2 h 20 min
• Cleaning	4 h
• Monitoring + treatments	1 h 40 min
• Clean-out	40 min
• Sales	50 min
• Management	40 min
• Other	35 min
Weekly total	16 hours

TABLE 56 Example of weekly work plan

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Numbering kindlings and first check	x	x					
Weaning young and initial selection of future breeding animals		x					
Culling sick and unproductive females	x				x		
Filling in doe	x						

cards							
Second selection of future breeding animals at 70 days		x					
Cleaning equipment and building		x		x			
Health inspection of animals and nest boxes		x			x		
Palpating does mated two weeks earlier			x				
Mating of females that				x	xx		

kindled the previous week and does empty when palpated								
Setting up nest boxes					x			
Filling In buck cards					x			
Routine activities (supervision, feeding)	xx	xx	xx	xx	xx	xx	x	

Note: x = operation to be performed on day marked.

Some production targets

Table 57 shows the performance records since 1983 of selected French rabbitries monitored under technico/economic management. It covers more than 1100 production units for the last year. The parameters change little from one year to the next.

The main productivity criterion is the number of progeny per breeding doe per year. The average here is 46 young rabbits for the year 1992. Strikingly, the range of performance around this mean is great: in the 275 most productive units (the top quarter), the output was 58.7 young rabbits sold per doe. The yearly renewal rate of does of 131 percent means that in order to maintain 100 breeding females year-round, 131 new does must be introduced each year, i.e. the average productive life of a doe is just over nine months (365 days ÷ 1.31 = 279 days) between the first mating and withdrawal (culled or dead).

Basically, the average production per doe depends on the theoretical breeding rate set by the breeder (in France the doe is presented to the male eight to ten days after kindling), the ratio of kindlings to mating (73.3 percent in 1992), litter size at birth, and the survival rate of newborn rabbits.

TABLE 57 Annual production performance in France from 1983 to 1992 in rabbitries monitored under technico-economic

management

	1983	1985	1987	1989	1991	1992
Number of rabbitries	404	488	661	543	922	1101
Number of does per production unit	148	174	196	216	241	256
Percentage of annual renewal	141	157	155	144	135	131
Kindlings/mating	68	69	70	72	72	73
Kindlings per doe per year	7.4	7.4	7.5	7.4	7.2	7.2
Total newborn in litter	8.3	8.6	8.6	8.7	9.0	9.1
Birth-weaning mortality,	21.3	24.3	22.0	19.4	19.4	19.1
of which stillborn	7.4	7.0	6.4	5.9	5.5	5.5
Mortality at weaning/sale	14.9	12.4	12.5	13.7	12.7	12.9
Number weaned per doe per year	48.4	48.0	50.1	52.2	52.1	52.9
Number sold per doe per year	41.1	42.1	43.8	45.0	45.5	46.0
Average live weight at sale *(kg)*	2.33	2.34	2.30	2.34	2.34	2.36
kg of feed/kg of sale weight	4.37	4.22	4.18	4.13	3.97	3.95

Source: Koehl, 1993.

A further 25 percent of these rabbits are lost before sale. Technically, the range is also great here, with the best breeders selling a little over 90 percent of their liveborn rabbits.

Economically, the consumption index is a major item. Under French conditions, feed accounts for over 50 percent of all production costs, including labour. In 1991 for the first time, breeders spent a little over 4 kg feed to produce 1 kg of rabbit for sale, including the feed consumed by rabbits sold, breeding does, bucks and replacement breeding animals. In different economic conditions the portion of feed cost price may vary, but it is always the major expense item.

Various external agencies (research or development agencies, private firms) may collect weekly data on production performance and evaluate the parameters for the purpose of helping breeders collect and analyse these technical criteria, keeping the breeder abreast of performance at all times. Computer programs can provide the same information at the production-unit level, but regular comparisons with other rabbitries will highlight weak points for the breeder.

Economic management

As with keeping technical records, not all producers have the same needs in economic management, which mainly concerns those whose purpose is to make the maximum profit.

There is a great deal of variation in this area. Results depend on the expertise of the breeder and his or her economic situation, so there is not much point in giving absolute figures.

Table 58 shows the relative importance of the various cost items for a group of 18 French breeders followed in 1991. Figures are given in percentage of turnover.

TABLE 58 Cost schedules in French production units as a percentage of annual turnover: averages and values for the upper and lower thirds of rabbitries classified by doe productivity

	Lower third	Average	Upper third
Number of progeny per doe per	37.0	45.5	54.3

Number of progeny per doe per year	[illegible]	[illegible]	[illegible]
Feed	56.4	52.0	49.8
Energy + water	4.0	3.7	3.7
Health	3.3	3,9	3.0
Breeding animals	2.1	2.8	2.7
Total operational costs	**65.8**	**62.4**	**59.2**
Write-off and financial costs	9.6	8.0	5.9
Social costs	2.4	2.2	1.8
Insurance and miscellaneous	3.2	4.9	4.1
Total structural charges	**15.2**	**15.1**	**11.8**
Labour (= net margin)	19.1	22.5	29.0

Sources: GELRA, 1992; Koehl, 1992.

TABLE 59 Influence of various factors on income of a French production unit

	Variation	**Improvement**

Factor	**Absolute**	**Relative (%)**	**Relative income increase *(%)***
Fertility *(%)*	+ 5	+ 6.8	+ 14.6
Number born per litter	+ 1	+ 11.1	+ 35.7
Birth-weaning mortality *(%)*	- 5	- 25.8	+ 17.6
Mortality during fattening *(%)*	- 5	- 39.4	+ 17.6
Feed consumption per rabbit sold	- 1 kg	- 10.8	+ 12.6
Feed purchase price *(FF/100 kg)*	- 10 FF	- 6.2	+ 12.9
Rabbit sale price *(FF/kg live weight)*	+ 1 FF	+ 7.4	+ 32.4

Note: These results reflect French conditions. The various factors are interlinked and cannot, therefore, be added. Figures are indicative.

Sources: GELRA, 1992; Koehl, 1992.

To indicate variability, figures are also given for the six least-productive rabbitries (37 progeny per doe per year) and the six most productive rabbitries (over 54 progeny per doe per year). A major expense item, as stated, is feed purchases. Depending on productivity, the share of turnover used to pay wages ranges from 19 to 29 percent, even though the rabbitries in the study lie in the same French region and are thus economically comparable in terms of feed purchase price and rabbit sale price.

As always, the higher the level of investment the greater the unit productivity needed to write off these debts. Productivity should be expressed either as unit of investment or as working time, depending on which is the main local constraint.

Table 59 looks at the influence of various production factors on income. The findings are indicative and valid in French conditions for production levels close to those in Table 57.

Among the financial factors, sensitivity to sale prices for rabbit meat is very high. In these circumstances it is easy to see the advantage of direct sales.

Improvement in overall production has a substantial impact on producer income. Careful selection of genetic type will increase profits by increasing litter size under specific breeding conditions.

Chapter 8 PRODUCTION OF RABBIT SKINS AND HAIR FOR TEXTILES

Meat is definitely the main goal of rabbit production. Two by-products are usually also recovered from the skin: the pelt and the shorn hair, with no particular production constraint.

Angora rabbits, however, are produced solely for the hair. The only way the producer can be sure of quality hair is to apply a very specific methodology quite different from that used in meat-rabbit production.

The same can be said for the production of quality pelts from special strains such as the Rex. The appropriate techniques, intended primarily to obtain a good pelt, make meat a by-product of the skin. Bearing in mind the special vocabulary used in the fur industry, this chapter includes a small glossary to help the reader with the definition of some specialized terms.

Rabbit skins: A by-product of meat

Rabbit fur production is not comparable with the production of other fur species. Mink, which tops the list of species bred essentially for its fur, supplies a world total of about 25 million to 35 million pelts a year whereas rabbit pelts are estimated at one billion. In France alone annual rabbit skin production tops 70 million.

Few skins are now retrieved from slaughterhouses: they are simply thrown away. Those that are used fall into three categories: fur pelts for dressing, pelts for shorn hair (hair removed from skin) and skins for use as fertilizer.

Origin of the by-product

Intensive meat-rabbit production techniques in Europe are usually incompatible with production standards for quality fur pelts. In fact, the raw skin represents only a small percentage of the value of the living animal. Thus more and more frequently rabbits are slaughtered at an age or time of year when their coats have not fully developed. This is usually at 10 to 12 weeks when they still have an infant coat or are beginning the subadult moult. These thin, unstable coats are not suitable for furs.

The only season when the adult coat is stable and homogeneous is winter. This is true of any animal over six months of age. The rest of the year there are always moult areas of greater or lesser size, so the coat is uneven and the hair is not firmly attached to the skin. Some summer coats can be homogeneous, especially those of rabbits that have completed the subadult moult, but the rabbits must be at least five months old. The summer coat is also thinner than the winter coat.

This rather inflexible growth cycle and seasonal changes in the coat make simultaneous fur and meat production a problem and so fur can only constitute a by-product, especially in intensive production. However, no research has been done on moulting patterns in subtropical countries; the figures given here only really apply to temperate regions.

The only quality skins are from adult rabbits, but the trend in modern rabbit production is to slaughter young, reducing the proportion of adult skins. In extensive production, rabbits are slaughtered at four to six months and this is the situation in many tropical countries. Therefore, quality skins could be produced in the tropics assuming the proper skinning and preserving techniques were used.

Sorting and grading pelts

Sorting. In an unsorted batch of rabbit skins valuable pelts can be found side by side with useless waste, so sorting and grading should be done as early as possible. Sorting, the first operation, determines the future use of the skin. Skins are sorted into three grades:

- *Pelts for dressing* (the term "dressing" instead of "tanning" is used for fur). These are the best skins, with regular shape, intact, homogeneous, dense, a well-formed coat, a flawless skin. Their price may be 20 times that of unsorted quality skins.

- *Pelts for shorn hair.* These usually lack the proper shape or are not homogeneous enough for fur products. The hair, however, is sufficiently long and healthy. It is therefore machine shorn and used for textiles or felting (although the hat trade is declining in many countries). The skin is cut into fine strips (vermicelli) and made into glue (another declining industry) or fertilizer. This technique allows much of the pelt to be recycled.

- *Waste,* unusable except for fertilizer (the hair is gnawed, cut, soiled, sweaty, parasite-ridden). Such skins push up the costs of labour, processing and transport.

In France, one of the foremost rabbit-producing countries, the proportion of pelts suitable for dressing is less than half of those collected. The figure differs from one author to another, which is not surprising in view of the difficulty in getting exact data on this product.

Classification. The customer buys the skins in commercial lots (from 0.5 to 5 tonnes) of matching quality.

The following grading system is used in France (and also in many other countries because of the number of French traders in the fur market).

For pelts for shorn hair.

- rejects - hair weight 10 to 18 percent of the dry pelt weight;
- ordinary - hair weight more than 18 percent of dry pelt weight;

- good quality, with guard hair removed - for glove-making.

For fur pelts. Grading is more complex for fur pelts, as colour, size and quality are all considered. The colours are white, range of grey, range of red (nankin), mixed and black.

Size is assessed by weight per 100 dry pelts:

- entre-deux: 12 to 13 kg/100 pelts (100 to 140 g per pelt);
- cage: 13 to 20 kg/100 pelts (150 to 210 g per pelt);
- heavy: 26 to 40 kg/100 pelts (250 to 350 g per pelt).

The gap between grades and the difference between weight per 100 pelts and unit weight stem from fluctuations in assessment.

Quality assessment covers the integrity of the pelt (proper cut, good fleshing, no knife marks or holes from skinning) and its structure (height of guard hair, compactness and height of downy undercoat and the homogeneity of the coat):

- pelts 4: poorest;
- pelts 3, 2 bis: medium;

- pelts 2 and 1: best.

This classification, which at first sight looks complex, is in fact relatively simple: traders and clients know exactly what merchandise is in question when they speak of a "cage 2 grey" or an "entre-deux 4 nankin".

The system, with slight variations, is the same in every country, understandably so considering rabbit pelts are an international trade item. In the United States, where rabbit production is not widespread and is undertaken by amateurs, United States Department of Agriculture grades are:

- firsts: no defects, thick and regular subhair. Used for furs;

- seconds: some hair defects and a certain lack of thickness, short subhair. For inferior fur and cutting;

- thirds: for cutting (felt) or toys;

- hatters: rejects, the best of which are used for cutting.

Firsts and seconds include five colours: white (price sometimes double that of colours as pelts can be dyed); red; blue; chinchilla; mixed.

Sorting and grading clearly show that it is in the interest of the breeder and the general economy of the country to produce the highest possible proportion of quality pelts or at least reduce the proportion of those which are unusable. It is also important to be able to constitute homogeneous commercial lots. This means that if production is low in a region the range of colours should be limited. The choice is not simple, given the ups and downs of fashion. The wisest choice would normally be white, as it generally commands a good price and once dyed can easily follow colour fashion trends. However, this is not the best advice at present, with long-haired fur in vogue and dyeing virtually in disuse.

White (not Angora) rabbit hair from shorn skins should not be considered a negligible item: it accounts for several thousand tonnes on the world market. France usually exports 100 to 200 tonnes of rabbit hair every year, and imports slightly less. Prices can be quite high: in 1984 to 1985 they held steady at 250 to 300 FF/kg, whereas the usual price is about 100 FF/kg as in 1992.

Production of quality furs

The main barrier to quality pelt production is slaughter age: the pelt must be big enough and the whole coat mature: i.e. a winter coat. The crucial times are moulting - juvenile moults for growing rabbits and seasonal moults for adults.

Quite apart from rabbits slaughtered too young and those raised under poor conditions, the two major defects that make rabbit fur a downmarket product are the fragile guard hairs (long coarse hairs in the coat) which break off very easily and the unequal growth of the hair during adult seasonal moulting (zones with shorter or looser hairs).

The Rex rabbit is free of the first defect because the coat contains no guard hairs, an advantage that places Rex furs in a select category of fur classification.

The second defect can be ironed out by production techniques that synchronize moulting in all parts of the body. The combination of this technique with Rex production has made it possible for some rabbit fur to attain formerly unthinkable pinnacles of quality.

Moulting

Seasonal moults in adults. Seasonal moults in adults, which are ruled by seasonal photoperiodicity, occur in spring and autumn. The spring moults are spectacular, with visible loss of winter hair, but they are slow and irregular and rarely give an entirely stable coat in summer. This summer coat, thin and short, is not among the most prized - it weighs only 50 g. The autumn moult, on the other hand, reactivates all the hair follicles in a relatively short time. It gives longer hairs and above all multiplies the secondary hair follicles which produce part of the undercoat. The winter coat, which remains stable for several months, weighs approximately 80 g. This coat is the most highly prized of all and often the only one used by furriers. In addition, the network of collagen fibres of the derma is contracted and produces a finer and stronger skin.

It is obviously preferable in a temperate climate to slaughter the animal at the onset of winter, as soon as the coat is mature, to ensure the least possible deterioration of the hair. Unfortunately no detailed study has been made in tropical or equatorial climates.

Juvenile coats. There are three types of juvenile coat: that of the newborn rabbit, infant coats and subadult coats. The first two are unusable because they are too small. The coat of the newborn rabbit stops growing when the animal reaches 0.4 kg (for an average size breed); it weighs only 8 to 10 g. The infant coat is mature at around nine weeks and its weight depends on the rabbit's weight, since the number of hair follicles in development depends on the size of the skin area of the growing animal. If a rabbit weighs 0.5 kg at nine weeks it carries 15 g of hair, against 30 g for a rabbit weighing 1.1 kg. The coat is thus still light in weight and the hair is fine.

The subadult coat becomes more interesting but the lengthy (four or five weeks) moult which produces it does not start until the rabbit reaches 1.7 to 1.9 kg. It matures, at the earliest, at four to five months (usually five). The weight of the coat, and hence hair length and density, also depends on the season in which the hair develops: 40 g in summer, 60 g in autumn or in winter, which is acceptable given the skin area. The subadult coat is therefore the first coat that could provide a fur.

As a consequence, it is very difficult to obtain pelts for fur in intensive meat-production systems (slaughter at 11 weeks). However, a breeder might attempt to produce acceptable pelts for shorn hair by using simple measures.

It is however quite possible to produce fur pelts under extensive production systems, by not pushing the animals' growth, feeding them a cheap but balanced diet and slaughtering them at the age of five or six months during the winter. It is also possible to produce fur pelts in intensive systems, provided that the rules detailed below are obeyed.

Conditions for quality fur production

Light. Newborn and subadult moults are not really ruled by seasonal photoperiodicity. They can be induced earlier by artificial lighting, but this calls for sophisticated installations (windowless housing) and the technique is complex (two different fattening periods with separate light regimes).

Temperature does not govern moults, but if it is too hot the discomfort will make the rabbit eat less, and the coat will suffer accordingly.

***Hygiene**.* Any physiological imbalance or pathological disorder has immediate repercussions on the coat, even if it has reached maturity. It becomes dull and unkempt, the secretion of the sebaceous glands is disturbed and the rabbit neglects its grooming. A skin collected in this condition will never make a good fur. Normal hygienic procedures, valid whatever the production system, also favour the production of a quality pelt and help to avoid diseases which specifically affect the skin. This will be one of the most difficult problems for developing countries.

Choice of breed and selection

In making this choice there are two factors above all to be considered with relation to grading pelts: colour and size.

Colour is a question of fashion but, as mentioned earlier, white is the most suitable as it is impervious to fashion changes because it can be dyed. It must be remembered that the trader is interested only in lots of four or five tonnes. Large pelts are the most prized; without going so far as to produce giant rabbits this means that midget breeds should be rejected.

Finally, there is the structure of the coat: it should be homogeneous, with long hair and a thick undercoat well covered with silky guard hair.

As has already been mentioned, the Rex breed produces an interesting and original pelt which is softer to the touch but tougher, recalling prestige furs such as chinchilla, moleskin or otter.

Collection, preservation and storage of pelts

Skinning

Skinning should be carried out in a manner that ensures the largest possible skin surface, which is an important part of its value. The first cut is usually an incision at the hind feet, passing from one thigh to the other. The skin is then pulled off. The skin on the head is of no commercial value but it is preferable to keep it because it allows better stretching.

This operation should be done with care to avoid mutilation, knife marks, grease (which oxidizes and burns the skin) or bloodstains. All these defects reduce the value of the pelt, especially when the coat is originally of good quality. The sequence of skinning operations is illustrated in Figure 48.

Preservation

Rabbit pelts are preserved by drying. This is a simple operation which can be done anywhere and costs little (the salt used to preserve the skins of other species can be expensive). Drying should start immediately after the skin has been removed. It must cool off quickly and dry out to prevent the action of enzymes in the derma which attack the hair root and cause the hair to fall. If fresh pelts are left in a pile for even a short time (more than 15 minutes) a rapid bacterial fermentation will set in and cause the hair to fall out in patches. Many pelts are lost this way through lack of elementary care.

The skins are shaped on a frame. They should not be excessively stretched, nor should there be any creases. The frame can be a board or a steel wire frame (Figure 49). Straw should not be used as padding as it can deform the pelt in places.

During drying, air should circulate freely and the skins should not come into contact with one another. It is unacceptable to accelerate drying by exposing the skins to the sun or to hot air; above 50°C the collagen of the derma is altered irreversibly and the skin cannot be processed. They should be dried in the shade or in the dark in a well-aired dry place (optimum temperature 18° to 22°C).

Twenty-four hours later it is best to remove fatty deposits on the shoulders and belly to avoid local hotspots.

Packaging and storage

The pelts are arranged in piles when they are perfectly dry in a cool airy room, with insecticide (naphthaline) between each layer of skin. It is best to grade the pelts without delay, the grading being more or less elaborate according to the size of the stock in question. At least the different qualities should be separated immediately and the white pelts from the coloured.

Whether the destination of the pelt is fur or hair production, all operations from skinning to storage must be carried out with care and attention. The slightest fault in handling results in a lowering of grade, which is all the more serious when a high-quality skin is involved and all the work carried out previously is lost. The greater the homogeneity and quality of the pelts the more attractive they will be to the trader, which is particularly important at times of market depression.

If it is intended to extend rabbit production in a country for the profitable sale of the pelts, training should not be underestimated. Training will be needed not only in production, particularly in teaching producers how to recognize the state of maturity, but also in the care needed in skinning the animal and in preserving and storing the pelt. Experience with hides and skins of other species shows the extent of losses due to negligence (in some countries only one pelt remains from every three animals slaughtered). Perhaps bad habits can more easily be avoided when a new animal-production sector is introduced.

***FIGURE 48 Skinning a rabbit -* 1 Shin cut between the thighs**

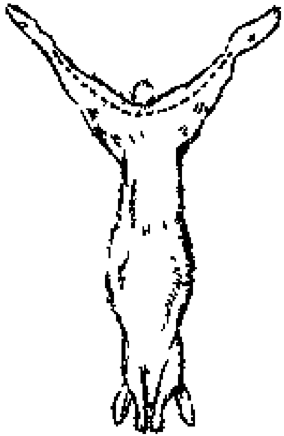


***FIGURE 48 Skinning a rabbit* - 2 Skin pulled off the hind legs**

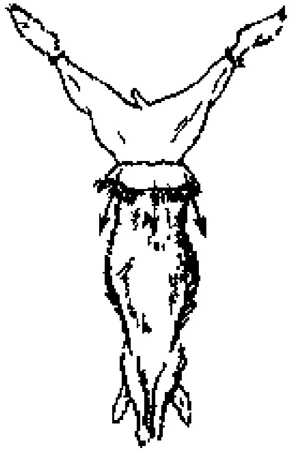


***FIGURE 48 Skinning a rabbit* - 3 Skin pulled to bare the trunk and then the forelegs**

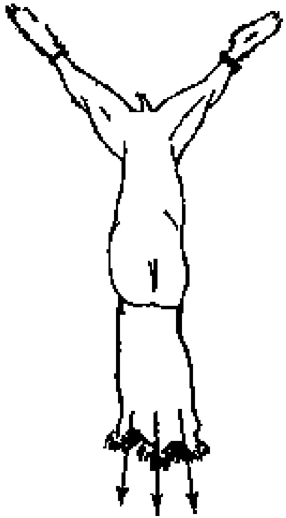


FIGURE 48 Skinning a rabbit **- 4 Carcass skinned but not eviscerated**

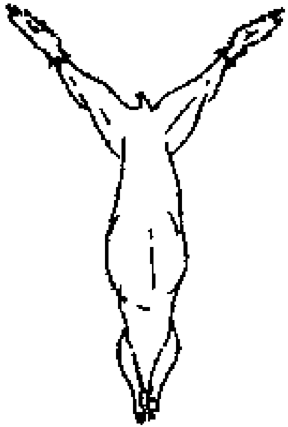
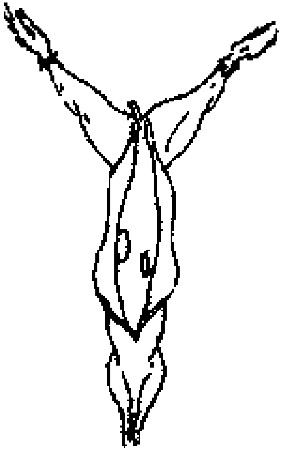


FIGURE 48 Skinning a rabbit **- 5 Carcass opened, white viscera (Intestinal tract and lungs) removed**



Curing and glossing

Developing countries are increasingly processing the cattle hides and sheep skins they produce. The first step is to turn out semi-finished products, for which the technology is simpler and more uniform, albeit demanding, and for which there is a wider market. Finished leather is a specialized product whose manufacture is far more delicate to undertake as expertise and imagination are both essential.

This is why developing countries are holding back their rough pelts to make semi-finished products such as wet-blues and hides (India, Pakistan). This system obviously has the advantage of using the local labour available, giving greater value to the exported product and facilitating packaging and storage.

Is the same development possible for rabbit pelts? This is difficult enough to answer with regard to other fur, which must always be perfect, and even more difficult for rabbit fur, towards which there is some consumer prejudice, also because European output, although of medium quality, is so high. On the other hand, shearing the pelt for the hair does not seem to pose any particular problem any more than does making use of the remainder of the skin, even if only for fertilizer. There is also the possible manufacture of small objects such as toys with pieces of low-quality fur; however, this is of relatively small economic importance and may involve difficulties with the hygiene regulations of potential importing countries.

Curing

Processing the pelt to the semi-finished stage requires a series of operations:

- dipping: rehydration of the pelts with water, salt and possibly soap, followed by rinsing;

- fleshing: the rabbit skin has a peculiarity, a thin collagenous film on the flesh side. This membrane, which is impervious to curing products, should be removed. This is a delicate, labour-intensive operation, carried out on the rehydrated skins;

- dressing: the special tanning for rabbit skins generally uses a specific blend of salt, alum and formol;

- thinning: it is necessary to thin down the thicker skins. This is highly specialized work, demanding great precision to avoid holes in the skin, cutting hair follicles and causing hair loss. A second dressing is carried out on the thinned skins;

- greasing: nourishing the skin with oil. This operation is labour-intensive;

- finishing: this gives the skin a pleasing appearance and consists of removing grease (stirring in a tub with absorbents), beating (tossing in a meshed cylinder to remove absorbents, sawdust, grit, kaolin) and lifting the hair to set it in place. Machines can be used for all three finishing stages.

***FIGURE 49 Correct way to dry rabbit pelts* (a)**

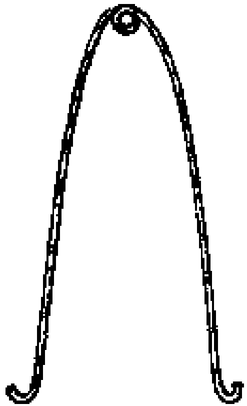


***FIGURE 49 Correct way to dry rabbit pelts* (b)**

Note: a = frame of thick steel wire (6 mm) if possible covered with plastic or sticking-paper; b = skin stretched over frame to dry, turned inside out with frame on inside, held down by clamps or domes pins.

Glossing

This is a complicated finishing operation, with variations such as shaving or colouring according to the final product required. It calls for much handling, expertise and imagination (mixing of dyes, special effects, etc.). These operations are too complex to describe here.

However, it is often the furrier who, having chosen a lot of rough furs, decides on the final appearance they will be given. For a coat, 20 to 30 skins will be needed. The making up of "bodies" (remnants of fur sewn together and sold by length), which is labour-intensive and not highly automated, can be done in developing countries or in countries where the labour is less expensive (Greece, the Republic of Korea and, for mink pelts, Taiwan, Province of China).

Conclusions on fur production

There is no hope of supplying quality furs under current rational production conditions for meat rabbits, particularly those slaughtered at 11 weeks. Skins, however, may be recovered for the three separate purposes of hair (felt), hides (fertilizer, glue) and sometimes dressed skins.

Quality pelts can be produced in extensive rabbit production systems if the producer is mindful of the moulting periods and waits until the subadult pelt is mature before slaughtering the young rabbit. The fur will be even thicker and more compact if slaughter is scheduled for a favourable photo period, i.e. when the days are short.

As regards the introduction or extension of rabbit production for pelts in developing countries, the following points should be considered:

- training of the future producer, specifically in the production of quality pelts;

- production of quality pelts in sufficient quantity to make up homogeneous lots for trade, concentrating on a limited number of pelt types, in particular as concerns colour;

- coat structure (density, silkiness) and the size of the skin are important considerations in selecting the breed. There is not much point in pinning great hopes on obtaining high-quality pelts in hot climates.

Upmarket furs can also be produced in rational systems provided special strains such as the Rex are used. The look and feel of this fur is now much in demand. There must be specific production techniques geared to fur production (meat, even though it may be of better quality, is here the by-product). Compared with conventional intensive production, the fattening units must be modified: windowless buildings for artificial illumination, large individual cages. The diet must also be modified (rationing) and slaughter specifically timed. Skinning, drying and preservation require great care. The skins are usually sold raw to furriers, for small-scale tanning operations often lack the qualities to produce high value added upmarket furs.

Angora

Angora, the hair of Angora rabbits, is one of the five keratinic textile fibres of animal origin of significant economic value. Wool from sheep is of course by far the main fibre, at over 1.3 million tonnes per year (thoroughly washed). The four others: mohair, angora, cashmere and alpaca, each at outputs of 5 000 to 30 000 tonnes, exhibit original qualities of fineness, lustre and feel for the production of high value added luxury items. Angora is often considered one of the "noble" fibres.

Angora: Characteristics

Textile properties

In the matter of textiles, "angora" without any other qualification refers solely to the hair produced by Angora rabbits.

Its International Organization for Standardization (ISO) symbol is WA: W for wool, reserved for noble textile hair, as opposed to H used for ordinary hair. The letter A is for the Angora rabbit and distinguishes it from the mohair produced by the Angora goat, M. The symbol for mohair is thus WM. The short hair of the ordinary rabbit is designated HK (K = Kaninchen which is "rabbit" in German).

Length*.* Angora hair is unusually long owing to the prolongation of the active phase of the hair follicle cycle: the hair grows for approximately 14 weeks, whereas that of the rabbit with ordinary (short) hair grows at the same rate but for only five weeks. This is due to the presence of a recessive gene in Angora rabbits.

Apart from this great length, there is no other modification either in the hair's structure or in the composition of the coat, which contains the three classic types of rabbit hair.

- guide hairs: the longest (10 to 11 cm) and the roughest; they cover and guide the coat;

- guard hairs ("barbes"): shorter than guide hairs (8 cm); their rough points lie on the coat and hermetically seal it (covering hair); four to each guide hair;

- down: shortest hair (6 cm); rounded point, hardly visible, very fine body (14 μ). Very numerous, 60 to a guide hair, they constitute the thermic isolation undercoat. The length of angora hair accounts for its textile value, because it permits cohesion in the thread.

Friction coefficient. The rabbit's hair has a characteristically low friction coefficient owing to the very slight relief of the cuticle scales. This results in a particular softness to the touch, but also an exceptional capacity for slipping. This is why the length of angora is important; the hair is twisted and stays in the thread. The use of ordinary rabbit hair to replace angora produces threads of bad quality which spread everywhere: this is a fraudulent process which reflects badly on the Angora industry.

Because of its softness angora hair is used for the manufacture of insulating underclothes (keratin). Ten percent angora in a mixture of wool, cotton and synthetic fibres makes an extremely soft fabric, very easy on the skin.

The kemp points and the covering hairs, which are more rigid, rise from the fabric, giving it a fluffy appearance which is much prized. Whole angora hairs obtained by depilation are the most suited for this purpose.

Other characteristics of angora hair

Although the Angora rabbit exists in all colours, only the albino strain is produced now. Its coat is entirely white, which is an advantage for dyeing. Coloured Angora rabbits are raised in India for the manufacture (by breeders themselves) of undyed artisanal fabric with muted colour motifs. The hairs are all medulated (hollow), which makes them lighter than wool (density 1.1 against 1.3) and increases their insulating properties. They have all the properties of keratin, notably insulation, water absorption and good dyeing quality.

Mini-glossary

Selected technical terms for fur production

Curing: tanning skins with hair.

Shearing: separating the hair from the skin in which it is implanted.

Knife marks: perforation or slit from skinner's knife.

Skinning: separating the skin (with hair) from the animal (carcass).

Brushing: gently brushing hair back into place at various stages in the curing process.

Pellicle: a thin collagenous film on the flesh side. The subskin muscle is removed with the dermis during skinning.

Fur: rabbit skin and hair.

Glossing: dyeing the hair of cured pelts.

Moulting: period of reactivation of hair follicle. The base of the former hair is hydrolized, freeing the hair canal for the emergence of the new hair.

Moulting zone: section of skin where hair follicles were active at slaughter. Seen as dark blue patches on the skin side of the pelt.

The hair comes out easily or is still very short, its growth interrupted by slaughter.

The Angora rabbit's coat is 98.5 percent pure as cutaneous secretions (restricted to those of the sebaceous glands) are very slight and the animal grooms itself frequently (a sheep's fleece is only 50 percent pure because of the presence of suint). Angora wool goes straight to the card without previous washing: it is imperative that the producer keep constant control over the cleanliness of the animals.

Commercial qualities

There are several grades of hair, identified by length, type of animal and cleanliness. First-quality hair which represents 70 percent of the coat must be over 6 cm in length (down) and clean. This grade was worth 950 FF a kg in 1984, but only 300 FF in 1981 to 1982. Since 1988, the price has ranged from 300 to 380 FF.

Second-quality hair is clean but too short (down less than 6 cm) or too woolly. It is grown on the belly and extremities and is worth about 20 percent less than the first-quality wool. The hair of the young Angora rabbit is shorter and softer. It is the product of the first and sometimes the second collection. The clean but felted hairs collected on the necks of females or breeding animals are worth only 15 percent of the value of first-quality hair.

Dirty hair of any length is virtually worthless. At best, it is worth less than shorn hair from ordinary rabbit breeds. Its value would be no more than 5 or 6 percent of the first quality. Clean hair is therefore absolutely essential in angora wool production.

Raising Angora rabbits

Angora rabbits are reared primarily for their hair. The production of this hair calls for an entirely different set of techniques from those used in meat-rabbit production. These techniques have historically reached the pinnacle of specialization in France, where the sole target has long been wool production, but some countries, headed by China, are now also developing this specialization.

Sexual balance. The adult female produces the hair: adult, because top-quality angora is only produced from the third collection at nine months, and female because the female produces more hair than the male - an average of 1 kg against 700 to 800 g for the male. Therefore the hair-producing stock is made up of adult females that are maintained as long as possible, with reproduction kept at a minimum. Gestation and especially lactation reduce hair production by one-third.

The number of breeding bucks is kept to a minimum. The proportion is only 2 or 3 percent in hair-production units. In France the males not destined for breeding are culled at birth, which hastens the development of the female young.

Harvesting schedule. The hair is collected every 90 to 100 days, when the follicles reach the resting stage and before hair starts falling, which would cause felting and reduce the value. The hair is cut with scissors or electric or manual shears, or collected by depilation. Depilation has long been the technique of choice in France, synchronizing the reactivation of hair follicles with a well-structured coat with good guide hairs. Since the 1980s French breeders have been using a depilatory fodder sold under the name Lagodendron^R (Société Proval, 27 rue de la gare de Reuilly, 75012 Paris). With careful use of this product, rabbits can be shaved more quickly and easily and less stressfully. Scissors is the more common technique in China, with shearing more common in Central Europe and South America. French-type Angora rabbit hair is better collected by depilation, whereas shearing or scissors are better for Chinese or German-type Angoras. The differences between their genotypes include, *inter alia,* the simultaneous resumption of hair follicle growth in accordance with the collection method.

Angora hair must be sorted into the different grades at collection, which is the best time. A skilled operator takes about half an hour: less than 20 minutes and more than 45 minutes are both very rare.

FIGURE 50 Comparative growth of hair types in Angora and common rabbits

Habitat

Angora rabbits must be reared in single cages, at least after the age of two months when the hair is first collected. The cage must be big enough (about 0.5 m^2) and high enough (about 0.5 m). Wire-mesh floors are rarely recommended. Angora rabbits, particularly French ones, have very fragile paws for their weight of roughly 4 kg. As they are to be kept for several years it is better not to take chances.

French breeders have opted for cement hutches and straw litter, for clean hair and paw protection. The straw absorbs the urine. A little fresh straw is added each week and the entire litter changed every four or five weeks. Duckboard has been a frequent choice in other countries, with the slats made of bamboo (as in China) or plastic. Some breeders, for example in India, use German-type Angoras and have successfully raised them on wire-mesh floors as for meat-rabbit production (see Chapter 6).

Angoras do not like high temperatures (over 30°C). Low temperatures are a problem as well (below 10°C), but only during the days following hair collection. It is therefore not necessary to heat all production buildings (in fact open-air production has long been the practice in France); on the other hand, the denuded rabbit must be protected, particularly where depilation is the collection technique. Breeders use several methods: two-stage depilation at intervals of a few days, leaving a "back" which is subsequently removed; body-coat, warmers, post-depilation boxes, etc.

Feeding and hygiene

Feeding Angora rabbits involves several peculiarities compared with meat rabbits. Indeed, the Angora at peak production is an adult rabbit in a situation of maintenance from the physiological standpoint. Its growth is complete and reproduction is limited to a few animals. It must, however, produce over 2 kg of dry proteins a year -more than 1 kg of keratin (hair) and the same amount from the internal sheath of the hair follicle. This is the equivalent of 7 or 8 kg of muscle.

This explains the need for a high-protein diet - 17 percent. The keratin in the hair is rich in sulphur amino acids, exporting 35 g of sulphur a year, so the proper intake of these amino acids (0.8 percent in the ration) must be ensured. The high productivity of modern Angora strains (up to 1 400 g per year), make full productivity difficult under traditional feeds such as hay, alfalfa, oats, barley, etc. The amounts would be excessive and deficits in sulphur amino acids inevitable. For cost considerations (excluding labour costs) some French breeders still combine these feeds with balanced concentrates containing methionine, vitamin and mineral supplements. Almost all breeders use only pelleted feeds for Angoras which are easy to administer. In this case an average 170 to 180 g should be fed to each rabbit daily.

The Angora rabbit's feed requirements follow the cycle of collection (every three months) and hair regrowth. Requirements increase after depilation as the animal is then hairless and energy losses by radiation are very great. By the second month the animal is again well covered, but this is when the hair grows fastest so the ration must of course remain adequate. In the third month, requirements decrease because the hair grows more slowly and, as collection time approaches, starts to fall. Daily rations need to be adjusted carefully to these variable requirements.

It is now the practice to give 190 to 210 g per day of dry matter during the first month, 170 to 180 g during the second month and 140 to 150 g during the third month. This is less imperative when the wool is sheared. It is also recommended that the rabbits not be fed one day a week so the stomach can empty, preventing or at least diminishing the risk of the hair balls that can form from self-grooming (very hard balls called trichobezoars that obstruct the pylorus and usually end in death).

Most losses of adult Angoras occur during the days following hair collection as the animals then have problems maintaining thermal balance. They become particularly sensitive to respiratory germs (pasteurella, coryza, etc.). The breeder must therefore be constantly on the alert regarding their general hygiene (frequent litter renewal, cleaning, disinfecting). Having to replace working females with young does lowers average production levels because first-year Angora output is appreciably lower: 650 g compared with 1 kg. The usual yearly rate of renewal is 25 to 35 percent.

Labour

Labour in Angora rabbit production may be subdivided into five categories:

- feeding;
- hair collection;
- cleaning and disinfection of the buildings;
- curative or preventive health care (vaccinations);
- reproduction.

Feeding is not labour-intensive provided the breeder distributes only balanced pelleted feeds in easily accessible feeders. In this case 40 minutes per day and 210 hours per year would be needed for a production unit of 400 Angora rabbits. The time is doubled for coarse feed such as hay and cereals. A daily distribution of straw or roughage, including fasting days, transport and sifting of feed must be reckoned in, raising the time spent on feeding to 400 hours per year.

Hair collection is the most time-consuming operation. The calculation needs to include not only the actual hair removal by shearing, cutting or depilation but also moving the rabbit from its hutch to the collecting table, the grooming phase to remove filth or plant matter from the coat, weighing different grades of hair, keeping records, returning the rabbit to the hutch, plus postharvest thermal stress reduction measures. All in all, some 1 000 hours per year are required for a 400-rabbit production unit.

Complete litter removal (cleaning) for hutches or cleaning out wire-mesh cages, disinfection procedures and sweeping takes at least 250 hours per year.

Veterinary care is basically preventive: vaccinations and general disease prevention can take up to 175 hours per year.

Reproduction-related work (handling breeding animals, checking gestation and kindling, sexing newborn rabbits, weaning) also requires 175 hours per year.

In all, a production unit of 400 Angora rabbits requires 2 000 working hours per year under rational production conditions.

Sources of variation in angora hair production

Genetic estimates of different strains

Although there are several strains of Angora rabbit, only the German, French and Chinese (Tanghang, Wan, etc.) strains are of economic interest at this time. The Chinese strains (including the German strain reared in China and South America) supply over 95 percent of the angora hair sold in the world. The European, French and German strains deserve mention for their specific features and because they have been selected for over 50 years.

Weight production. Hair-weight production has long been the sole focus in Angora rabbit selection. These genetic improvement efforts in France and Germany have produced highly similar acceleration of hair growth.

The annual output of does at the INRA experimental production unit in France rose from 885 g/year in 1980 to 1 086 g/year in 1986, a phenotypical gain of 31 g/year. Animals tested at the *Neu-Ulrichstein Hesse Centre* in Germany gained in productivity from 400 g/year in 1945 to 1 350 g/year in 1986: a phenotypical gain of 32 g/year. Production in the French and German commercial sectors lagged slightly behind these figures with an estimated annual production per doe of 1000 g/year under French and 1200 g/year under German production conditions.

There are major gaps in China by province and by production systems. The figures range from 261 g/year (unspecified Chinese strain, 1985) to 815 g/year (Wan strain, 1992) for does. Production conditions, particularly feeding, are highly influential because German rabbits under Chinese conditions are, according to the literature, producing from 422 to 820 g/year.

Non-genetic factors in quantitative hair output

Most of these factors are known today. The most important, judging by weight at each collection, is of course the interval between two collections. This effect is attenuated when considering annual output.

The collection technique (shearing or depilation) is an important factor, particularly for the (depilated) French strain, as shearing reduces adult doe productivity by about 30 percent.

The number of the hair collection is important up to the fifth collection for French strains: the first four collections successively represent 11 percent, 60 percent, 81 percent and 93 percent of adult production. The German strain is apparently more precocious, with several references citing the fourth and even the third collection as representing full potential productivity.

The sex factor is very marked in the French strain: male rabbits produce 20 percent less hair. This is not so true of the German strain, where the literature reports a difference of zero to 15 percent, with most citing a figure of 10 percent less for male rabbits. Live weight is fairly irrelevant, except during the growth period, but should be correlated with the collection number (first, second, etc.).

The seasonal factor should also be taken into account: winter collection is always heavier than summer collection, varying by 4 to 30 percent depending on the author. It does seem that the higher the productivity of the strain, the weaker the seasonal effect.

Other variation factors such as the season of birth have been studied, but new data are needed to confirm these findings. Undeniably, other factors such as diet (deficiencies), temperature and comfort do have a direct influence on quantitative productivity of hair.

Non-genetic variation factors in qualitative hair production

Angora hair quality parameters are length, the fineness of the down, guard-hair diameter and fur structure and composition. Concerning this last point, the basic distinction is between woolly fur and fur thick in guard hairs. The latter, in accordance with the proposed classification presented to the 1992 Corvallis Convention, include those in which over 70 percent of the guard hairs are full (i.e. with pointed ends) and where less than 1 percent of the fibre is shorter than 15 mm. The other furs are considered woolly. Felting or dirty fur is also considered a quality parameter.

The interval between hair collections is a decisive factor in hair length.

In the distinction between guard hair - obtained by depilation and woolly hair obtained by shearing, the collection procedure is fundamental.

The number of the collection is important (at least at the first harvest) for all rabbit strains and for the second and third collections in French strains, where the young rabbits still produce woolly fur, even after depilation.

The sex factor is less of a distinction and is weaker in the German than in the French strain but males do show a more marked tendency towards felting.

Live weight and season have less effect in adults; at most there is a structural difference: the length ratio of underfur to guard hair is less in summer than winter: 55 percent in summer as opposed to 65 percent in winter.

Prospects for angora wool production

A point to be considered very carefully is that Angora rabbit production is labour-intensive and also requires great expertise. The slightest mistake can mean the loss of productive adults: the animals have to be over a year old to return a profit. Hair collection is always a delicate operation and careless sorting irredeemably downgrades the product. Above all, not all climates are suitable: excessive heat and intense light (albinos) are very bad elements. In cold countries, or in countries with cold winters, the solution is to use buildings that shelter the animals against the rigours of the winter. Recently denuded animals require special care, however. The feed requirements of Angora rabbits are important: a poor, deficient diet will always mean qualitatively and quantitatively poor hair production.

Last and probably most important, the price of angora wool fluctuates: first, according to fashion, with a cycle of three to five years, but also and more abruptly, in classical supply and demand terms, when world production is structurally either excessive or insufficient compared with average utilization of the fibre. The price of angora (sheared wool) suddenly doubled between 1976 and 1978 (from US$13 to $28 per kilogram) because world production, estimated at 900 tonnes in 1977, was clearly insufficient. The price remained at this high level for about ten years, following the dollar; up to US$45 to $50/kg, and then in 1988, when world production had increased by a factor of ten to 9 000 tonnes, the market collapsed and the price had fallen to US$20/kg by the summer of 1991. There was a recent reversal of this slump in Chile, Argentina, Hungary and France (and China to a lesser extent), bringing the price up to US$30 in 1992. The volumes traded, and hence angora utilization, continue to rise: the production figure is likely to reach 10 000 tonnes per year again.

As for France, the only developed country to have maintained an angora output of original quality (the guard hair), the situation is one of unprecedented crisis. Production costs no longer permit the sale of French angora wool at less than US$75/kg and the gap between that and the world price appears immense to foreign buyers (the difference between world prices and the price for French angora conventionally being 40 to 50 percent). Quality French angora hair has remained virtually unexported since 1988, therefore, and is very difficult to market internally, either in the unprocessed form for manufacture or in manufactured form (e.g. sweaters).

Clearly this is a highly speculative production and should be approached with great caution. The utilization of the noble textile fibre, angora, continues to grow despite competition from other natural fibres and particularly from synthetic fibres. This is partly due to the new sectors that have opened, particularly for fabric, in combination with cashmere and silk. The price slump from 1987 to 1991 did indeed follow ten very favourable years, after decades of good angora prices. Better times could return again.

Chapter 9 RABBIT BREEDING AND RURAL DEVELOPMENT

The objective of this chapter is to present a case-study to show how rabbit production can help close the protein gap and raise the incomes of rural and suburban people in a great many countries. No attempt will be made to provide formulas for success - the various technical choices to be made will depend on the environment into which the rabbit is introduced. Instead the case history is used to demonstrate the questions that need to be asked in designing a programme like this and to determine the support structure needed for successful development in a traditional rural environment.

Generally speaking, the first task is to examine the external components of this kind of production system. There is a historical component, an environmental component, an animal component, a human component, and the socio-economic components (agriculture and stock-raising in the country, agrarian structure and industrial rabbit production). The interrelations among these various components should also be studied. They will reveal the advantages and constraints represented by rabbit production in reaching the objective: using local resources to supply animal proteins to rural families.

Next, the support structures and services available for development projects need to be investigated.

All these factors in combination comprise a community-level production system. Can the initial objective be attained? What are the potential bottlenecks? The components of a "model" programme tailored to the local circumstances should provide the answers to these questions.

The mexican "family packages" programme

Mexico has been chosen for the case-study analysis because it is unquestionably the country which has approached the problem most fully and systematically.

The example used is the *Paquetes familiares* (family packages) programme developed in Mexico by the *Dirección General de Avicultura y Especies Menores* (DGAEM). This rural development activity uses several backyard animals, including rabbits. The aim is to develop the production of poultry (chickens, turkeys, ducks), rabbits and bees, using local resources to produce quality animal proteins and honey, mainly for home consumption. The eventual marketing of products and by-products will raise community incomes.

Assisted by several rabbit production centres, the Mexican programme has a threefold mission:

- to inform producers, teach them all they need to know about rabbits, make them aware of the potential of rabbits, and draw the attention of the media to these actions;

- to train future breeders and experts/extension workers by teaching them the fundamental technical operations, making it clear that rabbits are not reared the same way as chickens;

- to produce the breeding animals Mexico needs for both industrial and backyard rabbit production.

In support of this programme, DGAEM conducts a number of experiments at its centres to test production techniques, installations, equipment and feed formulas in local conditions. The production techniques developed in these centres are then introduced into the target rural communities.

Historical background. The wild rabbit found in Mexico belongs to the genus *Silvilagus* Gray. There are several species - *Silvilagus andubonii,* found throughout most of Mexico; *Silvilagus brasilensis,* in the southeastern part of the country; *Silvilagus floridanus,* in central Mexico; *Silvilagus bachmani,* in Baja California; and, last, the Zacatuche, in the volcanic zone.

The wealth of names reveals how important this animal was in the past. Among the Aztecs, Tochtli (rabbit) is the eighth of the 20 signs central to the Aztec calendar. This monumental stone is far more than a simple calendar: it is a compendium of their cosmological view of the world. Tochtli had relations with Xipetote, the goddess of agriculture and good harvests. He was also the symbol of fertility. In the cosmogony he descends from Mextli, who represented the moon. The peoples of Central America saw a rabbit in the dark parts of the sky around the moon. Ometochtli (two rabbits) is the god of "pulque", the god of intoxicating drinks.

Despite this sometimes alarming symbolism, Fray Bartolome de las Casas in his book *Los Indios de México y Nueva España* reports that pre-Colombian peoples used rabbit skins for clothing and appreciated how well they kept out the cold. Rabbit meat was also eaten. Cortez's soldiers saw rabbit meat in the great markets (the famous *tianguis),* especially in the Aztec capital. The Spaniards later imported domestic rabbits of the species *Oryctolagus cuniculus* (Linnaeus, 1758) for the backyards of their *haciendas.*

Eating habits have regressed. Nowadays rabbit meat is unknown to most Mexicans. The individual intake is less than 100 g per person per year. In 1975, of the 127 people's markets in the Federal District only three had stands offering rabbit for sale. It is found on some weekdays in some supermarkets. Consumption is therefore limited to a small fringe of the urban population, especially in the Mexico City area (often people of European origin). Most Mexican people have never tasted rabbit meat. This unfamiliarity can make them suspicious or even hostile towards it.

The environment. *Oryctolagus cuniculus* is well adapted to the agroclimatic complex of its area of origin (the entire western Mediterranean). In the natural environment encountered in Mexico some areas are more favourable than others. Mexico is a tropical country lying north and south of the Tropic of Cancer. Its relatively large size (1970 000 km^2), impressive relief and mountain plateaus and the distance from north to south (about 2 000 km) explain the variety of climates and landscapes. The different combinations of latitude and altitude allow one to pass from a cool, temperate climate to a wet tropical one within a distance of a few hundred kilometres.

There are several large systems. In the centre a plateau area, the Altiplano, stands 1000 to 2 500 m above sea level. The climate is pleasant and healthy. Temperatures range from 15° to 25°C, and the difference between day and night temperatures is considerable. A dry season alternates with a wet one of the same length. Northwards, the dry season lengthens. The plateaus change, sometimes into true desert (the Great Sonora, Baja California) and sometimes into great, closed depressions dotted by oases. Further south the humid season is longer. The two mountain chains (the Sierra Madre) surrounding the plateaus converge to form a complex, low mountain system.

To the east the plateau slopes down to the Atlantic in a series of steps well watered by the humid winds, especially in the south. The further one goes the wetter it gets. The plains become semi-aquatic in the state of Tabasco. The next region is Yucatán, a calcareous peninsula with shrubby vegetation.

The Pacific side to the west is a much steeper formation of crystalline rock. Well watered to the south, it is semi-desert in the north.

In this mosaic of agroclimatic zones that make up Mexico the rabbit prefers the temperate or cool zones of medium rainfall -the high plateau and the Atlantic or Pacific slopes. As rabbits need a certain amount of water and forage their adaptation to the desert and semi-desert zones would pose some problems. Rabbits also dislike heat more than cold. So the lowest, hottest areas have to be avoided.

However, trials in Colima, which has a hot, wet climate, show that the species has considerable potential for adaptation. Studies now under way should enable potential production areas to be better specified in the future and, possibly, the selection of genetic types adapted to these tropical zones. These factors emphasize the importance of local genetic types, where found.

While not every agroclimatic zone in Mexico is favourable for rabbits, some can be exploited in creative fashion. The "family packages" used by the DGAEM programme usually contain the species or combination of species that will achieve the target objective. These associations (turkey-rabbit, chicken-duck or turkey-bee, etc.) would be even more effective if reinforced with small ruminants such as goats or sheep or a monogastric species such as the pig. There are one or more combinations of domestic animals for each agroclimatic zone, the goal being to make the rural community self-sufficient in animal proteins by maximizing the local natural resources.

The animal component. Worldwide, rabbit production is fairly extensive. Rabbits are found in almost every climate. The use of local breeds, where found, should be promoted. The direct introduction of selected animals into production systems should be discouraged. These animals probably do not possess the necessary adaptability and also the strains almost all derive from just two breeds: the New Zealand White and the Californian. When imports are unavoidable, the rabbits should not be introduced directly into the rural environment, but rather studied for one or two generations in experimental stations where their reactions to their new environment can be observed.

The human component. The extraordinary population explosion in Mexico over the last few decades is both an advantage for the future and a serious problem. The population was 13 million in 1900. It doubled in 50 years and stood at 26 million in 1950. Twenty-two years later it had again doubled. Today the 80 million mark has been passed and a figure of 111 million will doubtless be reached by 2010.

Demographic pressure is stronger in the rural areas. The outcome is a general rural exodus, amplified by a large emigration flow to the United States. Between 1960 and 1970 the active farm population shrank by 15 percent in relative terms. At the same time it also increased in absolute terms. The problem of undernourishment in these areas therefore continues to grow more acute.

Socio-economic background. *A* look at Mexican agriculture is necessary to see the programme in its proper context. A historical footnote on agrarian reform is followed by a brief description of industrial rabbit production.

Agrarian reform. Agrarian reform began about 1910 during the Mexican Revolution, with the establishment of the *ejidos* (collective farms). *Ejidos were* either old rural communities whose former lands were restored to them, or *haciendas* (large estates dating from colonial times) confiscated and turned over to the farm labourers and tenant farmers working them and run as cooperatives. The process is not complete even today as there are still landless farmers in many areas. Of the arable lands 25 percent are still in the hands of landowners with more than 1 000 hectares. Despite the existence of laws protecting productive properties, the risk of expropriation holds investments to a very low level on these estates.

Each *ejido* member also received a collection of plots, but these proved to be too small. The farmer can grow enough maize and beans to feed his family, but that is all. Only one of his sons can succeed him; the others have to go elsewhere. Numerous efforts have been made by the government to finance the *ejidos* with non-agricultural capital but most of these have failed.

Mexican agriculture. The traditional Mexican diet consists of tortillas (thin, flat, unleavened maize cakes), red beans and pimientos. Long a grain exporter, Mexico has become an importer in recent years.

The growing consumption of animal products, especially in the cities, conceals the stagnation or even regression in meat consumption in rural areas. Agricultural output lags behind population growth. This is in part a result of the existence of a vast sector that is underproductive: 3.5 percent of the land supplies 54 percent of all agricultural production, while at the other extreme 50 percent of the cultivated land supplies only 4 percent of total output. Despite this Mexico still has great reserves: 3.3 million hectares could be added to the 24 million hectares of agricultural land.

The government seems determined to develop this potential by the reasonable exploitation of its oil profits. It is aiming at national food self-sufficiency before the end of this decade, and the *Sistema Alimentario Mexicano* was launched for this purpose. This is an ambitious goal. The unemployment figure resulting from this and the population growth should be noted here. Underemployment is chronic in the countryside. The Mexican peasant works an average of four months a year and the rest of the time cannot find any employment. Some try to improve their lot by doing several seasonal jobs.

Industrial rabbit production. Industrial rabbit production differs from the rural variety mainly in its objectives, which are to reap a profit by producing animal proteins for urban markets.

In the early 1970s some thought rabbits had a great role to play as suppliers of animal proteins for the steadily growing urban population swelled by the drift from the land. Entrepreneurs with capital to spare invested in rabbit production. They started by importing breeding animals and then marketed them. The market developed rapidly and many rabbitries sprang up.

At this point a number of negative factors began to emerge. The extremes of the climate had a depressing effect on intensive production. For better environmental control, costly buildings had to be constructed. Breeder expertise was scanty. There were serious problems with the feed because of the poor quality of the raw materials and the small amounts manufactured. Growing production costs were masked by the profits from the market for breeding animals. However, this market dried up in the end, so advertising campaigns were then mounted to stimulate the demand for rabbit meat.

Unfortunately there were no marketing structures. Supply and demand were never able to balance. The resulting instant overproduction caused a price slump. As production costs were high, many units closed down. Production dropped and demand was never met. The crisis dealt a lethal blow to the recently formed producers' organizations. They disappeared before they had had a chance to organize the market or reduce the number of negative factors. Neither of the two objectives was met, but industrial rabbit production did not disappear and continued throughout the 1980s. Colin (1993) believes there are several dozen rabbitries with 200 to 3 000 does, and many more with about 30 does. The sector is thought to produce about 2 500 tonnes of carcasses every year. Marketing systems favour home consumption and local markets. Mexicans sometimes eat rabbit in restaurants. Promotional efforts are frequent.

Advantages and drawbacks of rabbit production in rural Mexico

The objective. Rabbit protein production corresponds to different needs. In the earlier example, the object was to increase producer income and it led to the development of techniques to maximize output while trying to hold down costs. These two goals are hard to reconcile. Some producers choose to hold down costs, especially investments, and try to maximize output regardless. Rabbit production thus fulfilled a luxury market: the eating habits of the tourists swarming through parts of Mexico every year encouraged restaurants to broaden the menu.

But the need in the countryside is a vital one: the diet is heavily deficient in animal protein.

The level of need and what attempts are being made to satisfy it is the next question. There are four levels: the farm family, the village, the city and the nation. Needs at individual and village community levels are easy to meet. Home consumption by farm families offers all the advantages of short producer/consumer marketing circuits: bottlenecks in processing and marketing disappear.

At the urban level, one feasible solution would be industrial production on the outskirts of towns. Several problems arise: technical management of large-scale units must be mastered. Obviously, since technical problems easily outstrip the size of production units, the size barrier is soon reached. Rabbit marketing also needs to be organized: the people it is planned to supply must actually buy the product through existing channels. At the national level, there may be other justifications, such as foreign exchange from rabbit exports, as in Romania, Hungary and China.

***Rabbit production in rural Mexico**.* The first advantages of raising rabbits in small rural units are the intrinsic qualities of the species: its prolificacy, the quality of its meat and its faculty of adapting to varied environments. This last trait should be fully exploited in small units where mistakes will not entail the same drastic consequences as in large units with several hundred does.

The rabbit is a small animal. It requires few inputs (purchase of initial stock, buildings, etc.) and it is the right size for home consumption. It can be reared by workers lacking great physical strength: women, children and old people. It therefore allows these categories to be part of the family labour force.

Fibrous feed is an important part of the rabbit's diet, so it does not compete directly with humans for its food. This feature makes it highly complementary to other backyard animals (chickens, ducks, turkeys) or small ruminants (sheep, goats). It will make use of forages not otherwise used, kitchen and other wastes and so on. In addition to its meat it supplies certain useful by-products such as skins and excrement. Processing the skins could provide a little employment for rural labour. Tourism should provide an outlet for these products. In the Mexican climate, earthworms can be used to convert manure into fertilizer. This is a fairly important resource in areas where chemical fertilizers are virtually unknown.

However, there are disadvantages. Despite their adaptability, rabbits need a minimum of water and green or preserved forage and do not withstand humid heat very well.

Where rabbits are reared in cages their forage must be gathered and distributed. Rabbits cannot seek their own food like other domestic animals.

Rabbit is not a customary item in the Mexican diet. With some exceptions Mexicans are not acquainted with this meat and are often reluctant to try it.

Technical personnel trained in rabbit production are lacking. Even if the owner of a small unit can manage with labour that is not skilled, a certain minimum number of technical operations need to be mastered. A rabbit is not reared like a chicken, so rural producers have to be trained. They also need to be assisted with the technical problems that can crop up periodically: health and reproduction problems and so on.

Making good use of the advantages offered by the rabbit implies knowing more about the animal: its requirements *vis-a-vis* the environment, rearing techniques and the products it supplies. Another prerequisite is the availability of motivated labour.

The DGAEM: an action agency

This agency has been working with rabbits since 1969, but also works with many other species: chickens, turkeys, ducks, geese, bees and pigs. The family packages programme was developed in cooperation with other development organizations. The rabbit component of the programme covers information, training in technical expertise and extension, the production of breeding animals and technical assistance to breeders. DGAEM has its headquarters in Mexico City and numerous production centres throughout the country. The Irapuato National Rabbit Breeding Centre (State of Guanajuato) was set up in 1972. This is the only centre specializing in rabbit breeding; the other centres breed other animals as well as rabbits.

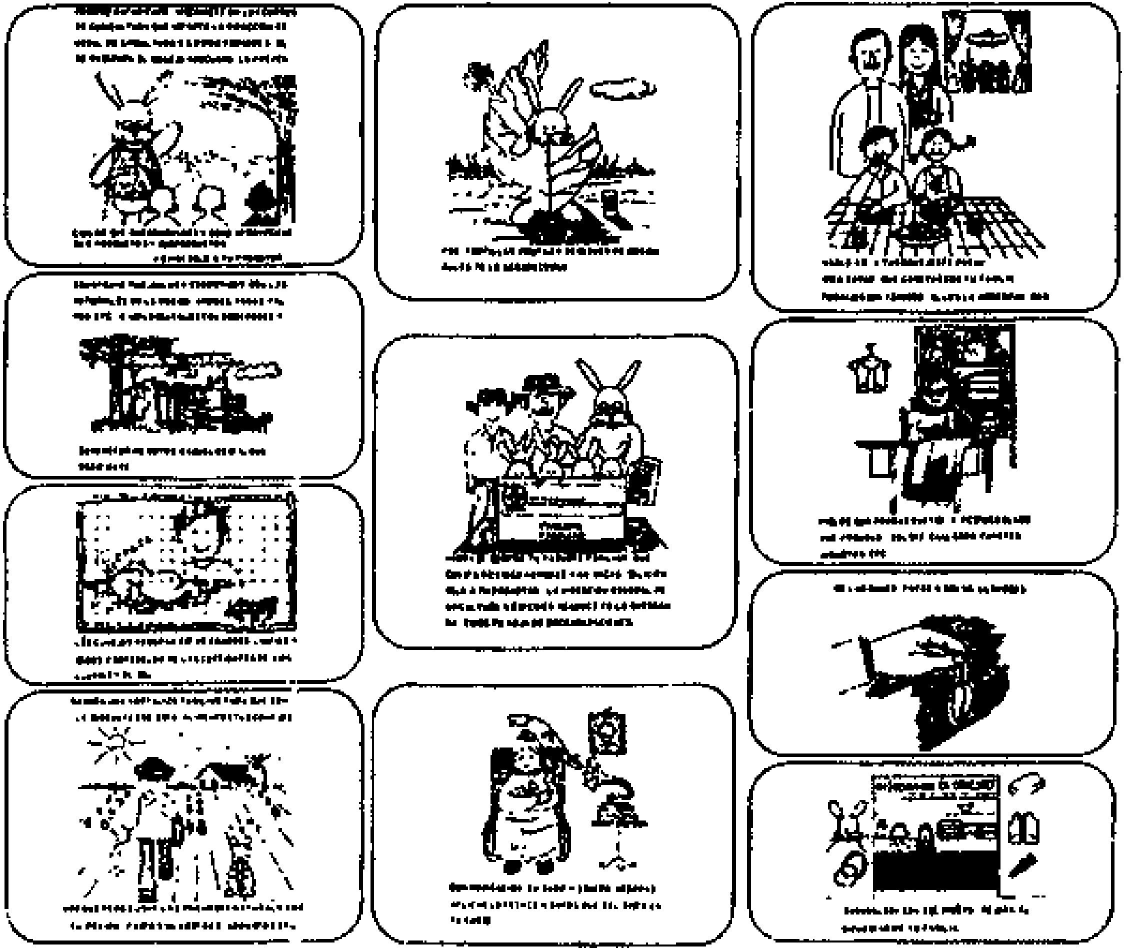
At the national level, information is prepared by a special department of the DGAEM. It issues brochures, reviews and other publications as well as audiovisual aids and any other appropriate teaching material to inform and interest farmers. It also assists other national and regional development agencies using the livestock species in which DGAEM specializes. It participates in agricultural and livestock fairs and keeps in contact with agencies abroad involved in the same work. A leaflet designed and drawn up by this department is published here to illustrate the work it does (Figure 51).

Promotion at the rural community level is the responsibility of a technician who usually works for another organization but has been trained in one of the DGAEM centres. This promoter is the key element in the field programme. The first step is to present the programme to municipal or, *ejido* authorities, explaining clearly the origin, development and aims of the programme and the benefits it offers the population. The promoter then organizes public meetings, visits families in the community and hands out the information documents provided by DGAEM, trying to enlist the cooperation of local primary or vocational school teachers. Experience has shown that children are very good at persuading their parents to accept a family package.

The promoter makes a list of interested families and with them examines how the family packages can be paid for. There are two ways of paying, in cash or in kind, with deferment for one year. For a package of one male and five does the farmer can pay back the same number of animals or seven dried skins. A community representative collaborates with the promoter and acts as guide on visits to the production units.

In addition to their technical training these agents have been taught communication techniques. A few simple ideas help them in their work. Every message seeks to produce a change so its purpose must appear clearly. The manner in which the person receiving the message interprets it depends on their skill in communicating, their level of knowledge and sociocultural environment. So the information should be as accessible as possible to the person for whom it is intended. The one issuing the message should make its purpose stand out clearly, choosing the most appropriate medium, from the leaflets/tapes, slides, films, posters, cinema and television available, each of which has its own advantages and should be carefully combined.

FIGURE 51 Example of leaflet circulated in Mexico for the promotion of rabbit production



Feedback is not overlooked. Public reaction is important as it enables some details to be corrected and shows whether the objectives are being met. The number of families in a community who have asked for family packages is a good yardstick of success. The evaluation process continues throughout the programme.

Training and extension in the family packages programme works on two levels: training the promoters who in turn train the producers. This is essential as DGAEM cannot afford direct training for all breeders receiving family packages.

Promoters are trained at the DGAEM centres in all livestock species handled by the programme. There are over 25 of these centres in the country. Courses are about 60 percent practice and 40 percent theory. The Irapuato course, for instance, lasts three weeks. This centre can take up to 50 students, including 30 boarders. The general course alternates with more specialized courses on production techniques and the use and tanning of skins. Similar courses are also offered at other DGAEM centres. DGAEM also organizes regular seminars on rabbit production techniques for the public. For action to be as effective as possible, the following rules are followed:

- standardization of the content of the various courses taking place throughout the country;

- no direct training of schoolchildren and farmers but focus of efforts on the teacher or development agent acting in the community, making use of the snowball effect;

- the teachers taking these courses are kept informed on rabbit production progress in Mexico and abroad;

- the establishment of a documentation centre;

- the periodical updating of technical booklets so that new knowledge can spread as quickly as possible.

Farmers receiving the family packages are trained by the promoter who is helped by the DGAEM, which supplies the necessary teaching materials. The promoter also offers direct assistance to families whenever the need arises. Particular attention must be given to the crucial stages of the programme:

- construction of cages and shelters;

- arrival of animals;
- feeding;
- mating;
- birth and weaning of young rabbits;
- fattening and slaughter;
- consumption of meat by producer's family;
- utilization of by-products.

Every month the promoter sends comments to the DGAEM centre which supplied the animals. The centre can then help if difficulties arise, such as a serious health problem. During the first year of operations an expert from the centre visits family package recipients once a month.

The production of breeding animals intended for the family packages programme is only one of the many functions of the DGAEM centres. DGAEM has set up a multilevel network. The Irapuato National Rabbit Centre has 1500 breeding rabbits of various genetic types. It provides a certain number of lines to other DGAEM centres which breed them to supply the rabbits in their family packages. Irapuato also looks after the distribution of family packages in its own area.

This scheme has the merit of being simple and effective. The distribution centres can get by with small stocks of each genetic type. They can obtain fresh stud stock periodically from Irapuato. One day, artificial insemination may make it possible to avoid transporting breeding animals over long distances.

It might seem strange to breed all the basic stock in the same place, given the diversity of climate areas. DGAEM is aware of this risk. However, the danger, if it exists, is serious only in the medium or long term. The various multiplication centres can test the reactions of the animals in their climatic environment and these animals could, if the need arose, constitute a core stock to begin setting up regional lines.

A centre the size of Irapuato has technical problems which are hard to overcome. Any country wishing to establish such a network should first acquire experience with medium-sized units before designing the central unit. Original solutions have enabled such problems to be very largely overcome in Mexico.

The Irapuato centre is first of all a production centre for breeding animals. It supplies pure-bred animals for other centres for multiplication and pure- or cross-bred animals, as needed, for the family packages.

Irapuato is also an experimental centre. One of its tasks is to constitute Mexican rabbit lines. To do this it has had to identify the animals (tattoo breeding animals, tag animals temporarily at weaning), organize performance checks (record litter size at birth, at weaning and at 70 days, as well as individual weight at weaning, at 70 days and at first mating) and process and utilize all these data. Production quality is a constant concern of the people in charge of the centre. This requires a meticulous review of all technical constraints and skilful organization of centre operations.

Staff activities are programmed on a weekly basis: weaning on Mondays, selection of future breeding animals on Tuesdays, palpating on Wednesdays, etc. Certain operations are done every day (feeding, inspection of nests). Such specialization is more efficient.

To facilitate the organization of the work, each doe is assigned a card. A system of colour-coded clips and pigeonholes in which to place these cards makes possible the simultaneous management of all females at the same physiological stage. Each buck and each litter have cards listing their productivity in weight and numbers. These cards are not only useful for the immediate management of the animals, they also help to choose the breeding animals to be culled and the stock to be used for replacement.

Production evaluations are made monthly in each building in the centre. These data are processed in the centre and sent to DGAEM headquarters in Mexico City. Each centre around the country sends in a monthly production balance sheet. The analysis of these monthly reports is extremely important for dealing with the technical problems arising in units of this size. Problems can be pinpointed rapidly, the causes analysed and attempts made to remedy them.

Irapuato is located on the Altiplano at 1700 m above sea level. The altitude tempers the effects of the tropical climate. Temperatures are relatively high. Diurnal variations are considerable, from 16° to 30°C in summer and from 8° to 25°C in winter. The dry season, October to May, is about the same length as the wet season. Rainfall often takes the form of storms that cause major swings in humidity, which can shoot up from 40 to 95 percent. The buildings have been designed and improved to offset these climatic swings as much as possible.

A conventional pelleted feed is given to breeding and fattening animals. Its use has led to a better understanding of some of the shortcomings mentioned in the section on industrial rabbit production. This feed is brittle and tends to crumble. Its fibre and nitrogen contents are far too variable.

The causes of these defects are many: uneven quality of raw materials, small quantities produced, which stops the feedstuffs manufacturers from making needed investments and so on. The problem of pelleted feed quality is one of the major barriers to technical success in large units such as the Irapuato centre. The animals could be fed green forage, but this solution has not been considered because it is labour-intensive. There is also no guarantee of the quality and reliable supply of forage.

In units the size of Irapuato poor control of animal health would soon lead to catastrophe. With some exceptions, individual treatment is seldom satisfactory in large-scale production and is very costly. The answer is prevention, with the focus on the group, not the individual animal. Constant attention is therefore given to preventive hygiene:

- regular cleaning and disinfecting of equipment and buildings;

- daily removal of dead animals, quarantine of sick animals, rapid examination of breeding animals at each mating;

- avoiding stress and contamination by personnel or inopportune visitors;

- control of other live vectors of contamination;

- regular analyses of feed composition and bacteriological quality of the water.

There are several types of rabbit in Irapuato. Three are crossed to make up the family packages. These rabbits were imported during the 1970s and their performances are highly satisfactory. They have adapted well to local production conditions. Mass selection is practised. The least-productive animals are culled and future breeding animals chosen from the litters of the best females.

In the New Zealand White and Chinchilla strains the standard criterion is the number of weaned rabbits per month of production. All the does in a building are entered on a double-entry worksheet (Figure 52).

After each weaning the keeper changes the position of the doe on the card. Does on the left-hand side of the sheet are to be culled as soon as possible; those on the right-hand side will produce the young replacement females and on the far right the replacement males. Culling and selection will be determined on the average level of production, to keep a constant total in the herd. The offspring of does in the central section will be for distribution to other centres and for family packages. The Californian strain is selected in the same way. The main criterion is growth rate between weaning and 70 days.

Reproduction is not intensive (mating 17 days after kindling; weaning at 42 days). Various experiments at Irapuato have shown that this system best reconciled quantity and quality under variable environmental conditions and where factors of production were not fully under control.

The organization of matings under one roof makes some selection possible while avoiding a too rapid increase in the average coefficient of inbreeding. To achieve these two conflicting goals each building is divided into breeding groups and matings are scheduled between these groups. This frees the keeper from having to check to see if the animals to be mated are related.

In the family packages a cross-bred female is included, say a Chinchilla × New Zealand White genotype. She will be supplied to the producer with a Californian male (Figure 53). This cross offers the advantage of heterosis. With several genetic types, numerous combinations are possible. Some are now being evaluated at Irapuato and in the family packages programme. The multiplication centres do not keep much stock of each genetic type. They receive Chinchilla and Californian males regularly from Irapuato. Basically these centres multiply New Zealand White females.

Liaison with other development organizations is necessary because DGAEM cannot provide technical support for each family package distributed. The promoters and extension agents who are indispensable in linking DGAEM to the rural communities belong to other organizations for this reason.

A programme such as family packages is just one component of an overall rural development strategy, itself a component of the national development plan. A global programme has to consider all the rural social questions of housing, health and hygiene, cultural activities and education. The promoter needs to integrate these components. To be effective, action must focus not at the family level but at the village community level. The fact that there are so many activities demands close coordination among the various bodies. While a simple administrative body may be inconceivable, a flexible support and coordination unit within an overall programme including family packages seems essential.

Promoters thus require multiple training. In addition to strictly technical matters they must be conversant with other, non-agricultural fields such as hygiene and pollution control. Moreover, if they are to get their message across, they must have some rudiments of the social sciences.

DGAEM officials are well aware of these two essentials - coordination with other development organizations and technical training for promoters-but there are many problems that have not yet been solved in practice. The failure of the family packages programme in some communities has been the result of inadequate training for promotion and poor coordination with the DGAEM centre supplying the animals.

FIGURE 52 Example of worksheet used for selecting does according to numerical productivity

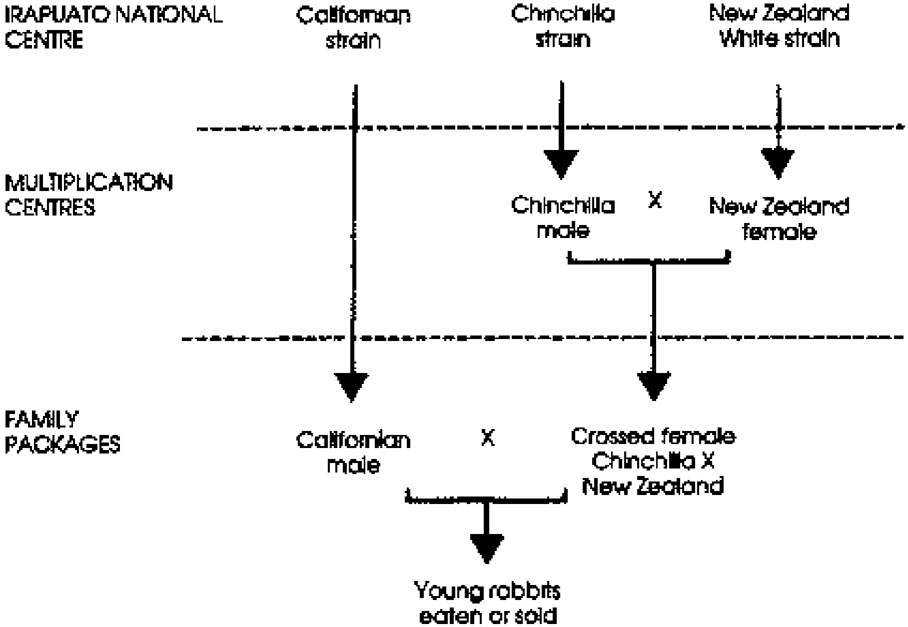
When the promoter has finished the publicity campaign he or she visits each interested family, noting their resources and the time they have available. The final list of applicants is then drawn up and sent to the director of the nearest DGAEM centre.

Now it is time to start making the cages to house the rabbits. Each adult breeding animal must have its own. During the postweaning fattening stage, however, several animals can occupy the same cage. So a group of one male and five females needs about ten cages. The materials and techniques used vary according to what is available. The community's own resources will be utilized to the utmost.

Each cage has a drinker and feeder or feed rack. The nest box is not always used when the floor of the cage is covered with straw litter, but is always recommended. In cold regions it is completely closed; in warmer areas it is left half open. In the hottest regions a simple wooden crate will suffice. It is lined with straw or wood shavings. To prevent the urine from collecting at the bottom several small holes are drilled in the floor of the nesting box.

Cages are always placed under some partial shelter from rain, wind, cold, direct sunshine and other extremes. Shelter design and placement must consider the total microclimate, especially the direction of the prevailing winds. Where predators are a threat, adequate protection will be needed to keep them away from the cages.

FIGURE 53 Example of cross-breeding based on three genetic types at Irapuato



When the cages are ready the promoter agrees on an arrival date for the animals with the DGAEM centre director. The animals are transported in a closed vehicle which protects them from sun and rain, in well-ventilated cages. They are given water every eight hours.

The first few days are the tricky period of adaptation. The promoter pays careful attention to the rabbits' behaviour. Three hours after their arrival they are given fresh water. For the following three days they are given only dry feed. After that they may be given green forage.

For their feed, maximum use is made of local forage resources and kitchen waste, or feed wastes of other animals, minimizing the competition with people for food. As part of the integrated rural development programme, families may be encouraged to plant kitchen gardens before the animals arrive. In some areas the promoter gives families kale seeds to plant. The aim is to find the cheapest feed while maintaining the animals at a certain production level. After a few weeks of adaptation, animals over the age of four and a half months are gradually bred, presenting one female to the male each week.

Palpating is a delicate technical operation so it is seldom performed. Nest boxes are systematically set up 25 days after mating. Ten days later, if the female has not kindled she is mated again. The rate of reproduction should be in keeping with available forage supplies. In some areas the females are not mated during the dry season.

Weaning takes place between 35 and 60 days. The aim is to obtain four litters per female a year, or 24 young, at an average rate of six per litter. The animals are slaughtered when they exceed a live weight of 2 to 2.5 kg. However, the producer does not slaughter an animal until it is needed. Fattening animals constitute a live larder from which the producer takes now and then, according to the family needs.

Regarding health care, almost all treatments are discouraged. A few simple rules of preventive hygiene are usually enough:

- give varied feed daily;
- ensure the structure adequately protects the rabbits from environmental stresses and predators;
- provide clean water;
- prevent the proliferation of flies and insects;
- regularly clean the installations;
- examine the animals every day so as to detect quickly abnormal behaviour;

- quarantine sick animals;
- keep recently acquired animals in quarantine;
- keep visits to a minimum.

The promoter uses commercial products to treat benign infections such as ear mange or injuries to the foot pads. In more serious cases the animals are let out into a closed pen measuring a few square metres and provided with a rough shelter. This is the best and least costly way of looking after them. If this does not produce results the sick animals must be culled. When a serious health problem affects the community as a whole, the promoter calls in a DGAEM expert.

When it is time to slaughter and eat the first rabbits, the promoter's teaching role becomes critical. The families have to learn to kill a rabbit cleanly, bleed it, cut it up and gut it. There is no better way than to give a demonstration right in the rabbitry. The promoter shows them how to clean the carcass and set the skin out to dry so that it can be used later.

To induce the family - and especially the children - to eat the rabbit, just a little imagination and the slightest persuasion are usually all that is necessary: imagination to prepare the rabbit according to a local recipe; persuasion to get one member of the family to agree to take the first bite. At the community level, a rabbit-tasting session could be arranged when the first young rabbits have reached slaughter age. DGAEM has published several booklets offering Mexican-style rabbit recipes.

There are many ways to use the by-products depending on the community context and the promoter will try to get the community to make the best and fullest use of them. Rabbit skins can provide the raw material for a small handcraft industry. Tanning will be done in a community workshop. DGAEM centres are equipped to teach these techniques. Many articles can be produced from the skins. The tanning workshop in the Irapuato centre, for example, makes bags, children's clothes and bed covers. Other parts of the rabbit can also be used, for example the paws and tails for keyrings.

The promoter ensures in advance that there are marketing outlets for these products, perhaps in one of the many tourist centres dotted about Mexico. Surplus meat can be sold to local restaurants.

Earthworms can convert excrement into fertilizer where the climate is suitable, and this can be spread on the family's kitchen garden.

The promoter must carefully follow up the development of the programme in the community. After the various preparatory stages have been completed it is the production stage that convinces the producer of the programme's benefits. The number of kilograms of meat produced per family is an important standard. This is the point that will attract the interest of other families and nearby communities.

The next phase is home consumption -the number of kilograms of carcass eaten by the family, especially the children, should be the basic standard of evaluation. Income generated by by-products and the sale of any surplus meat is another important item.

In supervising the programme the promoter notes the dates of visits to each family, progress made in the unit and the advice given. The information is summed up on an evaluation form and sent monthly to the DGAEM centre. On it the output of the family packages, the side benefits and also the problems are noted. This feedback is an essential part of the family packages programme, but in practice it is often difficult to obtain.

The situation in 1993

The programme just described has developed since the 1970s and productivity has shot up. Interest in rabbits declined in the early 1980s, output dropped and many problems appeared, primarily feed. Training and development activities were halted and the resources earmarked for the programme severely curtailed. The DGAEM disappeared and the Irapuato Centre staff were slashed by 75 percent. Centres such as Irapuato became state and not federal responsibilities.

The crowning touch in this decade of crisis for rabbit production was the appearance of viral haemorrhagic disease in late 1988. An exceptional control mechanism was soon in place. Vaccination was forbidden. Major information campaigns were broadcast on radio and television. The sources of infection were identified and all animals in contaminated production units culled. A figure of over 120 000 rabbits has been quoted. The rabbit breeders received damages and the units were restocked a few months later. The experts were amazed at the size of rabbit production in urban areas, particularly Mexico City (Finzi, 1991). This original strategy is thought to have cost US$22 million (Colin, 1994), but it seems to have worked. The information campaign did have a depressive effect on rabbit meat consumption, however.

This exemplary mobilization is an indication of Mexican interest in rabbits. The 1991 mission of Professor J. Galvez Morros culminated in a decision by Mexico to mount a new rabbit project with two components: to renovate the regional rabbit development centres and to reactivate training and development activities. The plan is to renew four centres: Irapuato with 1 500 does, Ixtacuixtla with 300, Aguascalientes with 200 and Xochimilco with 100. While the buildings can still be used, all equipment needs to be replaced.

The National Rabbit Centre has a triple mission: genetic improvement for supply to other centres; experimentation; and documentation. It is under the authority of the National Confederation of Livestock Producers.

State and private training and development efforts will be pooled. A survey will identify areas where the family packages programme is still functioning. Not enough competent technicians are available for training, and the rabbit development centres will therefore need to go into operation at the earliest possible date. The survey will also pinpoint what training is needed by rabbit breeders. For the development component, each state will run its own programme based on the DGAEM family packages programme. The feeding problem is as acute today as ever.

Colin (1994), in a recent summary of the state of rabbit production in Mexico, estimates a yearly output of 15 000 tonnes, 12 500 of which from family rabbitries. Mexico is a good illustration of the rabbit's great potential adaptability and also of the need for training. It is possible to develop family-scale rabbit breeding in a country where there is no firm tradition of rabbit meat consumption. Mexico is thus a model for many countries in the south that would like to see sustainable development of rabbit production.

A development programme using rabbits

A brief review of other rabbit development programmes in the southern countries concludes this chapter.

Benin is of particular interest (Kpodekon, 1988; Kpodekon, 1992; Kpodekon and Coudert, 1993). There is a lively tradition of rabbit husbandry in this West African country, the northern part of which has a tropical climate with a dry season running from November to April and a rainy season from May to October. Southern Benin has a sub-equatorial climate with two alternating dry and rainy seasons. Small family rabbitries averaging four does based on local resources are the usual pattern. Benin has set up a rabbit research and information centre (CECURI) to vitalize the sector. This centre, located on a university campus, has an experimental rabbit production unit. Its twin objectives are to promote expertise through research and development and extend rational rural rabbit production. The promoters of this centre insist on the need for local solutions to feeding, genetic and material problems. As in Mexico, the emphasis is on training for breeders and the need to listen carefully to their questions. This resource centre does need finance to operate, however, a problem requiring a clear political will favouring rabbit production. CECURI made spectacular technical progress between 1988 and 1991: fertility virtually doubled, litter size at birth rose by 30 percent and mortality was cut by a factor of between two and six. There again, the time factor is important: a centre of this type needs several years to reach cruising speed and iron out the main production problems. One final aspect that deserves emphasis is CECURI's 1992 organization of the First Regional Rabbit Congress, an indication of the need for cooperation between countries in resolving rabbit production development problems in tropical and equatorial Africa.

Unfortunately, as in Mexico, most rabbitries in Benin were decimated in late 1995 by viral haemorrhagic disease. A new rabbit development programme is currently under evaluation.

Lukefahr and Cheeke (1992) summarized their review of various development programmes in southern countries, particularly in Africa. In addition to the aspects of the Mexican programme already mentioned, they come up with a number of original ideas. In their view, the initial demand for rabbit development should come from the breeders themselves. They next suggest setting up a network of leading breeders, representing different villages, to follow programme developments and identify problems more quickly. Training is a major item and to be successful all trainers should also be breeders. They also agree with Kpodekon and Coudert that research and development programmes are crucial in solving local problems and they stress the need for reliable technical information.

Summary

Analysing a small rural rabbitry depends on a number of interacting factors. Not all operate on the same level: Figure 54 gives an idea of how they interconnect. The reader can either start from the centre and read outwards, or start from the outside and read inwards. The objectives are in the centre. Here the major goal is to produce proteins to feed the breeder's family. A secondary goal is to generate family income through sales and employment.

The first circle around the centre shows factors that directly affect achievement of the objectives. Double arrows show how several factors interact at the same level. The second circle contains a second series of factors. The plain arrows represent the action of one factor on another. The system considered here is only a subsystem, one component of a global system of rural development and links with the outside are barely indicated in the diagram.

The programme is executed by a national organization. This structure is responsible for developing the work. Its task is to inform, create awareness and provide training and evaluation. Local backup is provided by regional units which do the same job. The regional units do not train the producers directly; they train the technical people who are in touch with the field. This decentralization is essential to the effectiveness of the whole and to avoid the excessive growth of the organization that is technically responsible for the programme. The regional units produce and multiply the breeding animals. They may also act as centres for demonstration and experiment, where the animals' reactions to the production techniques and the agroclimatic conditions they will meet outside the centre can be tested.

This programme is one section of an integrated development programme. According to circumstances it might embody such features as production of other animal species, agronomy, horticulture, or perhaps home economics, hygiene or home renovations. Such integration requires good coordination between the executing agency and the other development agencies: some technical, others more concerned with socio-economic work.

In practice, liaison is through the promoter responsible for keeping the programme going. He will have been given basic training in rabbit production at one of the regional production centres. Preferably, he should have two years' experience in rearing rabbits. His training will also enable him to lead other programmes.

The sphere of action is the village community. To get these programmes off the ground at least ten families have to join. This number makes the agent's work more effective, promotes interest in the community and makes mutual assistance more effective. It also makes it unnecessary to include one male in each batch of five females. The promoter can distribute a number of males among the units and organize their use.

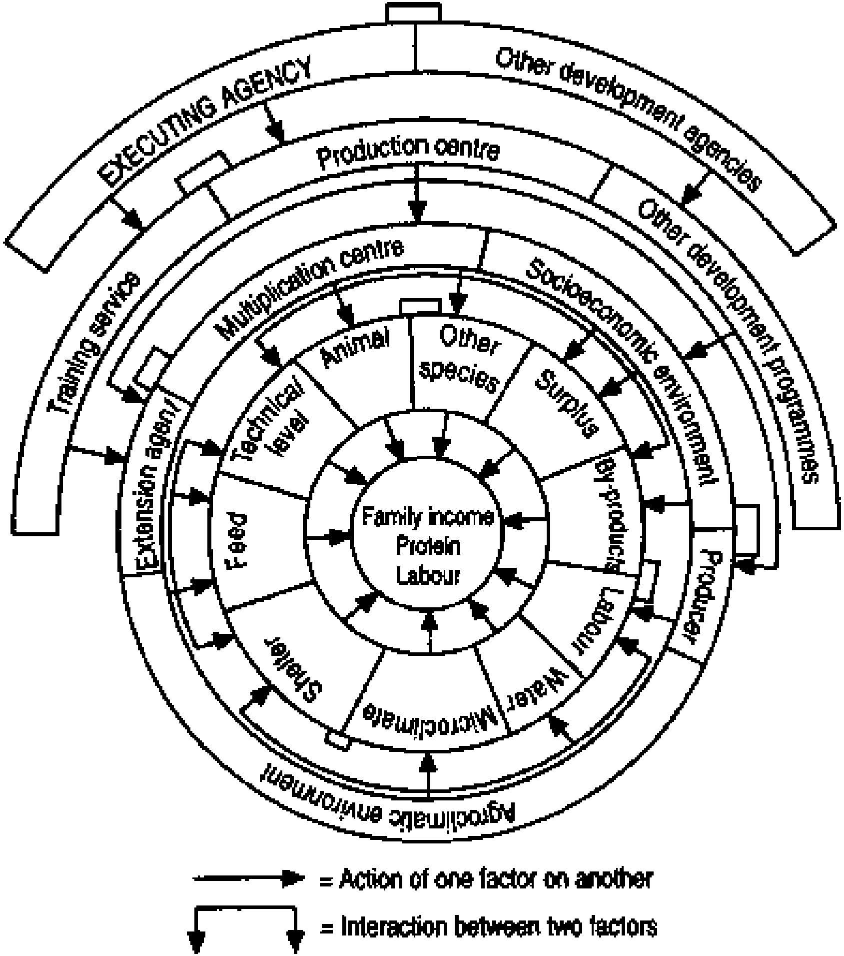
The promoter must be in constant contact with the local branches of each organization involved in the programme. Periodic reports will enable him to evaluate his work. Regional experts can rapidly detect problems that come up and help the promoter solve them. Feedback is essential for the system to run smoothly.

The human factor is a very basic component of this environment. The promoter has a primary role. It is he who arouses interest and enthusiasm, who provides information and who guides the rabbit breeders. He is both instructor and observer; he must not give up easily, but he must also be patient. He is largely responsible for the level of technical ability reached by the farmers.

It is hard to modify agroclimatic factors, so they must be exploited as much as possible. An inventory of regional forage resources often requires the intervention of an agrobotanist. Medicinal plants could be useful, for example. Water resources will be the subject of a separate study.

There is a great deal of interaction at this level. The reproduction rate adopted must be decided on the basis of alternating seasons and thus according to forage resources. Where fodder is abundant the production potential of the species can be fully exploited. During harder times, most of the animals will be eaten by the producer's family. He will keep only the future breeding animals. This extreme pattern is adapted to regions where the dry season lasts less than six months. Microclimate, locally available materials and available labour will also determine the type of cage and shelter to be used.

FIGURE 54 Global analysis of a development programme using rabbits



EXECUTING AGENCY
Other development agencies
Production centre
Other development programmes
Training service
Multiplication centre
Socioeconomic environment
Extension agent
Producer
Animal
Other species
Technical level
Surplus
By-products
Feed
Labour
Shelter
Microclimate
Water
Family income
Protein
Labour
Agroclimatic environment
= Action of one factor on another
= Interaction between two factors

The socio-economic factors depend partly on other development programmes. It is these that determine any sales outlets for eventual meat surpluses or by-products. Where there are enough by-products a small industry can be launched to provide a little work and generate some income for the community.

The animal factor should not be overlooked. A systematic evaluation of local genetic types will help to breed animals adapted to the local agroclimatic complex. A policy of cross-breeding to reinforce this adaptation to the environment and so upgrade productivity can be tried. Selection should take place in an environment not too different from the area where the producers work. In countries with several clearly defined climatic zones, selection should be done at the regional centres.

Rearing rabbits jointly with other animals such as domestic poultry (chicken, duck, turkey), small ruminants, bees or fish is often the best way to exploit the resources available.

Large-scale production of quality breeding animals is a difficult problem. One effective solution is to establish a network of multiplication centres based around one or more selection centres.

Other solutions could be devised. But anything less than full control of such technical parameters as feed quality, or climatic parameters such as temperature, will lead to productivity problems. It is therefore wise to limit the size of these regional units to a few hundred females at the start.

At the rural community level the promoter is responsible for finding the best combination of existing possibilities in the light of local constraints. There is probably no need to reiterate the importance of the work of this person and the need to reach an understanding with the community. Development programme success hinges on how well the promoter has understood their needs, expectations and motivations.

Programme evaluation should not be limited to a simple quantitative analysis. The standard "amount of rabbit meat eaten monthly by each family member" is important, but far too restrictive. An attempt should be made to evaluate the social impact and deep-seated transformations from a programme such as this. Evaluation, like programme design and follow-up, requires a multidisciplinary team. This should include an agronomist, a livestock expert, a sociologist and an economist, at the very least.

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