FONDAZIONE INIZIATIVE ZOOPROFILATTICHE E ZOOTECNICHE
BRESCIA

REARING OF RABBITS IN EMERGING COUNTRIES

CONFERENCE PROCEEDINGS

Brescia, October 21st 2022

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Conference Proceedings

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Scientific Director: Prof. MARIO COLOMBO

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PRESENTATION

These days talking about rabbits brings to mind pet bunnies. Whether large or small, straight- or floppy-eared, long or short haired, and with solid or spotted coats, they are the epitome of cuteness. However, rabbit used to be viewed as a tender, mild-tasting meat - and still is for many consumers. It was a watershed moment, and a tense one for the agrifood industry, when rabbits stopped being raised for food and started to be bred as cherished pets. During a previous conference held at the Fondazione Iniziative Zooprofilattiche e Zootecniche (Foundation for Zooprophylaxis and Zootechnical Initiatives) in Brescia, in-depth discussions focused on the critical issues faced by rabbit farmers across Italy. However, their resolve and determination were also underscored. Setting aside ideologies - carnivorous, omnivorous or vegetarian - rabbit meat is undoubtedly very versatile and lends itself to countless cuisines and dishes. Of course my opening remarks about attitudes toward rabbits apply only to Western societies, because in most countries where the laws that traditionally governed the advancement of humankind still apply, rabbits are viewed as livestock. This conference, and the proceedings published with it, aim to give rabbit farmers both large and small some useful guidance and insights into optimising their business. In tackling topics as far-reaching as structural issues, farm management and feeding practices, the goal is to reduce the risk of disease and improve the feed-to-protein conversion efficiency of rabbit meat from both the qualitative and quantitative standpoint.

Our "Quaderni", or Notebooks, are generally published only in Italian, but we have made an exception this time in order to broaden the appeal and readership of this first-rate volume.

We are confident that the technical content of the book will prove to be an effective tool for communities and populations who appreciate rabbit meat as an essential and high-quality source of protein.

The Scientific Director
Prof. MARIO COLOMBO

PREFACE

Rabbits are reared all over the world for meat and wool production and as pets, where in emerging countries they can still provide a great contribution to the achievement of more than one Sustainable Development Goal, such as No poverty, Zero hunger, Good health and wellbeing, Gender equality and Responsible production and consumption. In European Countries, many efforts are now addressed to develop alternative systems for farming rabbits in cage-free systems, indoor and outdoor, implementing management and biosecurity practices for the best health and welfare of animals. The results of these innovations could be incorporated in the design of new projects for the development of rabbit production in emerging countries.

However, this cannot be done without coming back to the experience of colleagues, like Prof. Alessandro Finzi of the University of Viterbo, that operated for long time under different conditions and scenarios all over the world, or without taking into account the recent projects developed by NGO associations, like Tamat Lapin project - with the support of Prof. Cesare Castellini of the University of Perugia - and ANAWIM AFRICA - with the support of Dr. Michele Schiavitto of ANCI-AIA. Finally, the LAGMED -PRIMA project, involving the researchers of the Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna, contributes to rabbit production development in emerging countries sharing knowledge and competencies among nine European and African Countries to face the spread of Lagoviruses that can endanger rabbit production in the Mediterranean basin.

That's why the Italian Association of Rabbit Science (ASIC) has proposed to the Fondazione Iniziative Zooprofilattiche of Brescia to organize this event, looking for new opportunities for rabbit production as a tool to improve food security and promote socio-economic development of people in emerging Countries, outlining strong and weak points of previous experiences. This event and the book including all the contributions of the invited speakers are dedicated to late Dr. Ennio Facchin, two times President of ASIC, Head of the Verona Section of the Istituto Zooprofilattico Sperimentale delle Venezie. He dedicated his entire life to rabbits, until his last days, with the final objective of giving more opportunities to the young people in less developed Countries. Thus, ASIC warmly thank the Fondazione and all the people who contributed to this event in the memory of our dear colleague and friend Ennio.

ANGELA TROCINO
President of the Italian
Rabbit Science Association

RABBIT KEEPING SYSTEMS IN DEVELOPING COUNTRIES

ALESSANDRO FINZI

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THE TRADITION AND THE ENVIRONMENT

Rabbit production in developing countries can be aimed at food security in poor rural areas or may also have a more or less important component of commercial goals in peri-urban areas. Only the first case is here considered because all the production means should be developed with local resources and local technologies, making the producers free and totally independent of future external aids. Materials should be original of the place, abundant, freely collected and, may be, recycled, no cost or very economical, while housing and equipment should be simple, appropriate, efficient, self or locally made, accepted by the users and easily imitated.
Moreover, this is the only way to make a project sustainable. If these conditions are not considered and everything is offered by the project, when materials are deteriorated and no longer utilizable new ones are asked again by the families who were not able to spare the money to buy them again and remain forever dependent on external support. On the contrary, if the project is successful, as soon as other people look at it, they understand that it is easy to imitate and start their own production unit. Many times, being these conditions respected, people come to see what the strangers are doing and, as soon as they understand, do the same, frequently even before the first prototype is finished and working.
It is difficult to convince people to do something they have never seen before. Thus, it is necessary to ask for help to do the work together. To work together is very important for the cooperator himself. If you have a problem, the local person knows the way to solve it. Only at the end, when also the appropriate specific management has been learnt, he will be very happy to know he has become the owner and he, at the end, had been working for himself. In this way, also the cooperator receives a lot of specific know-how.
Traditional rabbit keeping systems are very interesting and theyshould be known in advance to do a profitable work.It must also be remembered that local technologies are sustainable since they exist and are profitably maintained generation after generation, while most of the imported technologies generally fail, in rural areas, as soon as the technical and financial support is finished. There are cases where it is probably impossible to develop a raising system better than the one existing yet. Traditional systems are very clever and must be studied also to make some basic factors better understood by the cooperator.

The simplest system is shown in Figure 1. A very small unit formed by a colony of tiny local rabbits is housed under a bush of tamarisks at the border of the Sahara Desert. There is no fence, but all around there is the desert where rabbits could not escape. The burrows they dug under the bush are their housing place and there they remain all day long. They get out only at dusk to feed on the alfalfa brought from the oasis.
The only technical thing made by the owner is the very simple but important catching device. It is formed by a simple hole in the ground, 50x50 cm wide and 50 cm deep. The hole can be closed by a wooden lid. When alfalfa is put in the hole, as usual, all the rabbits immediately get out from their burrows and jump to feed into the hole where they can be easily caught closing the hole with the lid.
If we consider thatat,the border of the Sahara Desert the temperature during the day is always higher than 40 degrees, no rabbit could be raised in such environmental conditions. Unfortunately, rabbits have a very low thermotolerance in comparison with other species. They don't sweat and their way to lose heat by panting is very limited. In fact, their thermoregulation is not physiological but behavioural. In the warm hours of the summer days, they simply hide in their fresh burrows and get out to graze from the late afternoon till the early morning.

FIGURE 1. A free ranging colony of small rabbits.

In Figure 2, we can see that most regions where projects are starting to implement rabbit keeping are included in the area between the tropics and pay attention to the red line that represents the thermal equator. Most programs involving rabbit keeping are impaired by the hot environment. Thus, the low thermotolerance of rabbits is an important limiting factor that must be always considered when housing systems are to be planned.

All Central and most of South America are involved. The same is for Africa where the effect of Sahara Desert affect even the Mediterranean area that, being in the tropical belt, should be less affected. Going eastwards and leaving India for religious reasons, we found all the countries of the Malaysian Peninsula and all the Indonesian insular area where even governmental projects are aimed to rabbit keeping for food security at family level.
Many are the different people by which the cooperator must previously integrate himself with the specific socio-economic and cultural systems to obtain a true cooperative spirit and not a simple acceptation of what is offered gratis promising benefits that are obtainedvery rarely, while a general regression to the original ways of production and life is the most common result.

FIGURE 2. Most projects are in the equatorial area.

One thing must always kept in mind by the cooperator: if a traditional production system is found, the traditional system is surely sustainable being there and producing through time and generations. On the contrary the new system, supposed to be more modern and efficient, has still to show to be accepted and adopted in the specific social system. When new producing systems are accepted, the most important impairments are the cost of production in comparison with the market prices and the diffused fatalistic attitude in some cultures not to program the management forgetting mating or not feeding enough the rabbits, sometimes even considering that paying or working to feed an animal is diminishing the dignity of man.
Other traditional very efficient systems of rabbit keeping is shown in Figure 3. Again, they are at the border of the Sahara Desert where to raise rabbits should be impossible being the ambient temperature higher than 40°C along the daytime. In this case, all the structures are artificial. But they are simple, no cost and functional. According to the model in the Figure 3A, a rectangular area is dug about 50 cm deep and rab-

bits are introduced at its bottom. From there the animals dig their burrows. The area is limited by a low wall and usually covered by rags and tree branches.
Feeding is a technical part of the management. The grass to feed the animals normally comes from the oasis and also wastes of dates production are utilized. Feed is administered on the ground and when rabbits get out to feed a stone can be placed to close the exit and to catch them.
The deep pit (Figure 3B) can be till 2 m deep and at its bottom the temperature has been checked to be 9-10°C lower than the external one at noon in the shadow! To catch the animals, grass is thrown on the bottom and a boy can be lowered into the pit. In the best prototypes also, an oblique passage has been dug to allow rabbits to reach the surface in a rectangular space limited by a small stone wall where rabbits can be caught as already described.

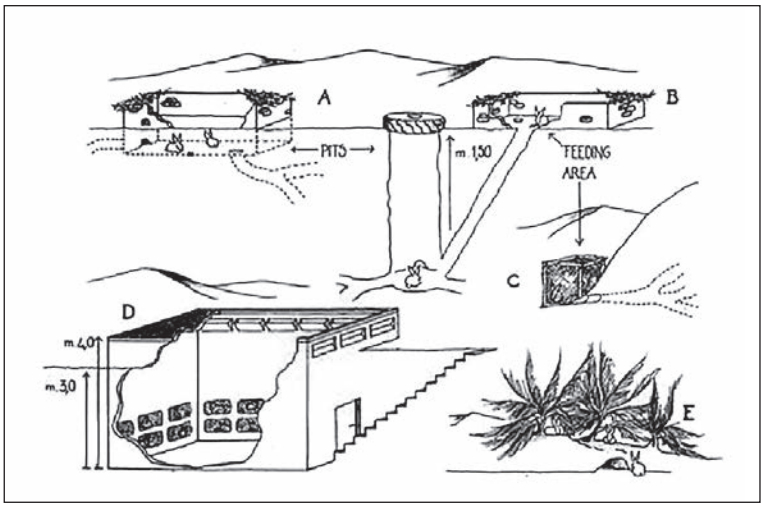

FIGURE 3. All the systems at the border of the Sahara Desert are underground.

The mouth of the pit is always limited by a car wasted tire that has the function of preventing the wind from carrying the sand and burying the pit. If a tire is seen in any place, even in a desert land, a good technician is able to immediately understand that itis a traditional rabbit keeping pit unit.
The pit system is obviously typical of no rainy zones as the desert ones because rains could fill the burrows; nevertheless, one was found in a rocky area in Mexico. The rain was not filtering and a roof was sufficient to make the unit functional.
A simplest but less common variant of the system is illustrated in Figure 3C. At the base of a solidified dune, a small entrance hole is prepared; from there rabbits dig their burrows into the dune. The exit is limited by a small protected area where rabbits can be fed and caught.
All these systems, including the one of Figure 3E that is the one illustrated in Figure 1, are traditional and perfectly sustainable. However, in Figure 3D one can see that a whole room has been built inside the ground. The door is placed at the bottom and

must be reached descending a stair. In the room two rows of cavities arranged inside the wall can be seen with the function of cages, but they were all empty, while a dozen of rabbits was freely ranging on the floor where they could drink and feed with alfalfa and bread. No nests or kits could be seen, but everything was recently cleaned, probably because of the programmed visit. It was clear that a lot of money was wasted to build an underground room where the cages could not be cleaned nor allowing to feed the rabbis. Only the environment was very fresh and comfortable. It was clear that not even the costs of building should be never recovered. In practice, only a fresh and very costly colony rabbit keeping system had been produced. It was interesting to know that bread could be fed to rabbits because, for social reasons, it was sold at a political price, lower that the one of the wheat to produce it. We note this to show that the cooperator must pay attention to frequent para-technical factors that many times can influence projects and their results, mainly because they are frequently unexpected and transitory.
All the keeping systems described were observed in Tunisia where family breeding is traditional and very common in the villages (59.2% of the houses randomly visited) and a good empiric knowledge of rabbits environmental needs was observed.
It is clear from these examples that the scarce thermo-tolerance of rabbis is a limiting factor in most of the countries where projects try to diffuse rabbit keeping aimed to food security. Thus, the best option is to try to imitate the ethologic behaviour offering rabbits the chance to hide in natural or artificial burrows in the ground. This also allows to spare the cost of conditioning the micro-environment that is becoming a limiting cost even in developed countries as a consequence of the increasing energy price.

THE INNOVATION: THE UNDERGROUND SYSTEM

Before my working in Tunisia and discovering so many different and interesting traditional rabbit keeping systems, I was sent to care a governmental project in Egypt. The situation was very promising: the Aswan dam had made a large area of the Nile valley fertile through irrigation and families had begun to settle to form small farms. The warm climate and the abundance of water allowed many annual cuts of alfalfa and the project of the Government was to provide some ducks and rabbits to support food security. I was sent as a FAO consultant and the mission was to provide suggestions about rabbits breeds and feeding.
It was immediately clear that the problems were not breed nor feeding, but how rabbits could be raised in such harsh climatic conditions where the environmental temperature was higher than 40°C many hours a day. The first shelter prototypes were then built according to the draft in Figure 4. As it can be seen, a cell was formed with handmade concrete slabs. The cell was later thermally insulated by a layer of earth and it was connected through a passage with an external cage which could be removed to allow cleaning. The cage was done protecting by the inside with a wire net a cheap reed once used for transporting chickens. The system simulated the natural conditions; it was immediately tested and all the does sheltered inside the cell during the hot hours of the day getting out in late afternoon for a few minutes only to feed or drink. Clay cells and conic shapes were also tested. Before the end of the project, we got also the first parturition into the underground cell.

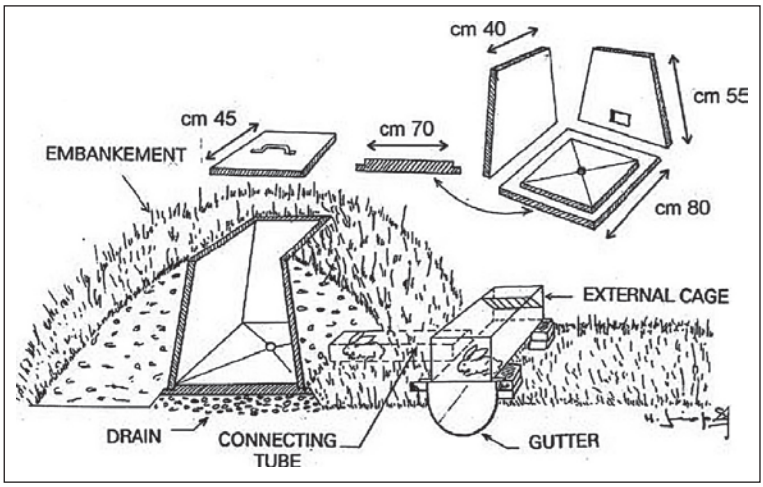

FIGURE 4. Draft of the underground cell system.

Many small units soon started in the area by simple imitation, but always the cells were substituted by cheap clay vases bought in the market. Being the vases too small to contain also the nest, a smaller vase was connected to the biggest one in function of nest. In this way, the basic idea was accepted and immediately adapted to the local conditions. For this reason, at the end, the demonstrative unit of the Project was built according to the basic idea, readapted to local culture.

By a lucky coincidence to make possible a comparison, it happened that the small innovative rural units started in the area at the same time of a large industrial farm equipped with feedmill and slaughterhouse. At that time, rabbits and chickens were still sold alive even in the big market of Alexandria and there were not refrigerators where meat could be stored. Anyway, the calculated cost of production was clearly predicting that the company would go bankrupt very soon.

Two years later, I was to a congress in Egypt and I was looking for the technician who had worked with me. He was able to lead me to visit the backyard unit of a producer with whom I had collaborated observing how he had originally grasped the idea and adapted it to his technical skills. I was surprised to see that rabbits were everywhere in the yard and also freely entering in the house. The explanation was simple: the man was keeping all the rabbits produced, even if they had passed the correct slaughtering time, because Ramadan was coming and the meat was intended for the traditional night dinners. This was one of the few times in which the result of consulting could be checked, the consultations being always too short to allow the control of one complete reproduction cycle at least. Probably I was lucky because the traditional know-how to raise rabbits is common in Egypt and people can easily adopt and adapt simple innovative technologies.

I asked then what happened with the big rabbit farm and the answer was that it was going well. I could not believe and I succeeded to get a visit because, if so, my predictions were wrong. In fact everything was abandoned with the great surprise of my

technician who was not able to learn my teaching. This is a good example of how, without an analysis of the socio-economic conditions, the magnitude of the investment does not guarantee the success.
NOTE 1: when a rabbit is newly located in an underground cell, the passage to the cell must be blocked in advanced and the rabbit must remain closed into the cage at least two days to give time the rabbit to choose the place to make its drops. When the animals are conditioned in this way, the cell will remain clean. On the contrary, it will be impossible to keep the cell clean. This is a management rule that must not to be forgotten.
NOTE 2: to raise rabbits in individual cells is important to diminish the risk of diffusion of sicknesses being avoided housing in common buildings especially where pharmaceutical products are scarcely available and the cost of medicines or vaccines for few rabbits are not sustainable.
In Italy the breeders can maintain perfect sanitary conditions only by management and by the Consortium in Viterbo any medical treatment is forbidden because it is sufficient to take care of isolate immediately any suspected case. From the beginning of the ninety's pharmacological treatments were abolished when the underground cell system was introduced. Vaccination was allowed but only recently began to be used though not regularly.

THE GENERAL CONDITIONS

Rabbits can be frequently seen freely ranging in the backyards together with poultry and even goats. All these animals must be fed and the cost of maintaining them is generally higher than to buy meat at the market. However, they are at quick disposal in case of fest or ceremonies or important guests. Their function is similar to that of a refrigerator for which we bear the cost of electricity in addition to that of purchase.
Another traditional system is formed by a small circular structure of overlapped stones with a diameter of about m 1.5 and similar height. The base is cemented to prevent rabbits from digging and the walls are covered with mud to obtain a sufficient thermal insulation.
Cages are common nowadays, but in rural areas they will never substitute the described original systems that have been developed according to rabbit ethology. Nevertheless, the use of cages has been introduced and widespread, mainly in peri-urban area, though this was increasing the costs and exposing the animal to the seasonal heath stress. The consequence is that mating is avoided during summer time the same as to have parturitions in such period.
In the traditional systems, being colony systems, any management of reproduction is made impossible and production is rather low. To get available information at this purpose is very difficult because output is always overestimated. The only practical way is to ask how many rabbits have been eaten, or sometimes sold, in the last three month. The information must be asked to the housekeeper who, having cooked the meat, can easily remember. Then it is easy to calculate the production according to the number of does. The technician must not be surprised if the result will be always

less than ten per doe per year, sometimes only five-or six. Nevertheless, with 5 does an output of only 25 slaughtered means that two rabbits a month can be an appreciable source of animal protein for the family.
Nowadays, rabbit keeping has become rather common mainly in the peri-urban areas where it is possible to get some income selling at a market live animal which are brought back home if not sold, while they should be wasted if slaughtered in advance and non-sold.
In addition, urban rabbit keeping has become very important. In towns as Alexandria in Egypt or Mexico City urban rabbit keeping is much more diffused and important than one can suppose. Rabbits are raised mainly on terraces, in basements or even inside a room and it has become an appreciable source of protein for the family. In these conditions, a production of 10 per doe per year must be considered a good result. In this case the summer stopping of reproduction and mating after weaning depending on the low nutritional level of the animals, not considering mortality and bad management, are common limiting factors, too.
When the housing system must be chosen to develop a project, seasonal environmental temperatures should be previously considered. When cages are utilized in North Africa, mating is regulated in order to avoid reproduction in the hot season and stopped for about four months because animals do not even eat, lay panting and the effort of pregnancy and milking is not sustainable. In comparison with cages, the limiting factor of all the traditional colony systems is that it is impossible to control the reproduction and frequently the number of the animals is allowed to grow in excess and the individual reproduction rate is reduced because of social competition. However, the wellness of the animals with reference to heath stress is absolutely better in comparison with cage keeping.

THE CAGES

In rural European areas where rabbits are traditionally raised it is still easy to find wooden cages tall enough to hold a rack to administer the forage. Thus, it is difficult to understand why these cages are not considered by projects, though feeding is based on no cost grass or leaves, which can be easily collected and administered to the animals.
As long as I could observe only metal or wooden cages similar to the industrial ones are used and it is supposed that, administering also concentrated feed, the better production that can be obtained could not be easily sold in the market why not competing with rabbits produced with a cheaper feedstuff. Only in one case, the tall wooden cages provided of a rack were observed.
A lucky mission gave me the chance to observe the comparison between the two systems as if it was in experimental conditions. In the island of Sâo Tomé, the Portuguese colonizers had built big wooden cages provided of racks for hay or grass, similar to the ones also still common in many Italian rural families. Thanks to the rainy warm climate, any quantity of roughage was easily collected to feed rabbits and all the farms raised them in a well shadowed and relatively fresher area. However, at

the beginning of decolonization, the Portugueses had left the country and the beautiful and rich cocoa farms were abandoned. The new local authorities asked then for a Czechoslovakian consultancy to start again with rabbit production and they put groups of standard metal cages under straw roofs, planning to feed the animals with industrial pelleted feed that had to be imported. When the consultancy left and the reserve of pelleted feed finished it was clear that the system was too expensive and not sustainable. Thus, they began again to feed rabbits with grass, which was introduced into the cages where the does were obliged to jump upon it and the grass was immediately soiled and wasted.

A social aspect was also observed: all the African people working in the Portuguese farms where able to raise rabbits, while the ones recently arrived from the continent were not. Unfortunately, only the latter where employed to raise rabbit and the result was a mess.

A new consultancy was then asked and I got involved. In my report, I explained that there was no other chance than reactivate the old Portuguese wooden cages and give them to be managed by the old worker of the farms accustomed to manage the rabbits and to feed them with the rich and no cost vegetal biomasses easily harvested in the near bush. As to say, they had to come back to the efficient traditional system of the colonizers!

Considering that the workers of the farms were fallen in poverty, I supposed it was part of my mission to try to allow them to raise rabbits for themselves, being able to do it. The first problem was then that all the town shops had closed and it was impossible even to find nails. Not surrendering I thought that it was possible to build no-nails bamboo cages with an interlocking system. I found then that it was possible to tie bamboos with vegetal self-made cords out of the reach of rabbit teeth, but the big problem was that we did not succeed to tie them each other perpendicularly. At the end, an Austrian technician which was a boy-scout in his youth thought me how easy it was to tie correctly and I could build a very beautiful bamboo cage. I report this anecdote to recommend to ask always how to solve a problem to any person you meet because many times I got it from a person unexpected to know the solution.

However, a final result of a consultancy is not always achieved. When I said that leaving the few necessary instrument to be used by anyone, bamboo could be collected by people to build cages and rabbit keeping could start again, but the answer was that bamboos were property of the State and none could touch them! This is another example of a para-technical condition that, being unknown to the consultant, determines a negative result though all technical problems had been solved.

Not knowing the Portuguese, I wrote my report in Spanish that is easily understood, but it was refused because Sâo Tomé is considered part of the francophone West Africa and I was obliged to write again my report in French. Will they not understand? No matter, this was the FAO rule!

The work of the consultant is not always easy and successful. One must be prepared and remember to ask and ask again because any kind of information can be decisive. I am sure that, if not started again with proper cages and management, rabbit keeping is no longer existing in Sâo Tomé where it was so diffuse, profitable and even beautiful.

To offer metal cages and some rabbis as a gift is often the naïve proposal on which many rabbits farming projects are based. For instance, this was the choice of a Governmental project in Mexico where the conditions were very favourable because the autochthonous people were accustomed to eat rabbit meat of the hunted local wild species and raising and eating rabbits was traditional in the Spanish population. The technicians showed me the small shelters with the empty cages and explained that reviewing the project six month later they did not find any rabbit. People said that the rabbits were dead, but the technicians thought they were eaten.
My experience suggests that cages, does and a buck were offered to rural people and, of course, they accepted. They knew rabbits but they did not know how to breed them. Failure was sure. However, I have observed that frequently feeding the animals is also not sufficient. In a unit of a rural school, the cages were not bad, but all rabbits had died by starving. Knowing of the visit, the professor had fled. There was only a skinny rabbit left. It too had to die by starving, so I provided some grass and the rabbit began slowly to eat and died. At least it died eating.

All these examples lead to the conclusion that a way must be found, if possible, to administer fodder using industrial metal cages. Nevertheless, it is possible to do it with wooden cages of similar shape. For instance, in the beautiful and perfect cage shown in Figure 5 you can see that the lid is formed by a wire net with big holes. The grass is placed on the net and the holes are large enough for rabbits to catch it. Administration is easy and grass is not wasted. Cages like this one can be done also using a frame of welded metal bars. However, wood has been chosen more frequently as soon as local people understand how to do the work. Nevertheless, it is necessary to avoid a very common mistake: the wire net must be nailed or tied with iron wire inside the frame to avoid rabbits to gnaw it, as clearly shown in Figure 5.

FIGURE 5. Building a cage for rabbits in Mexico.

The floor of the cage in Figure 5 was made tying small bars of a hard local wood. Local rabbits were rather small and it was necessary to establish the optimal distance between the slats of the floor. To do this, two small pieces of wood were cut to the same size as the largest of the droppings so that they could fall under the cage, but the paws of the kids were protected.
To make easy to clean the floors of the cages, these can be tied under the cages and easily substituted to be washed and exposed to the sun to be disinfected.

THE IMPROVED WARREN

The frequency of the presence of free ranging rabbits in the backyards where they dig everywhere has posed the question if a small technologized warren could be proposed. In Figure 6, a project is illustrated which was proposed on the basis of experimental results adapted to local technologies. As it can be seen, a traditional fence has been built with a defense against predators at its top, while at the bottom the base is reinforced by recycled metal bins lids, as once it was observed as a clever local innovation. Inside the fence, a heap of straw or hay can be seen. Rabbits dig always their burrows inside the straw and stop digging in the ground where pups could be easily drowned in case of rains. The system has been developed by the Centre in Viterbo where it has been tested for many years and adopted by some farmers. Near to the heap of straw, a siphon clay drinker can be seen that have been many times tested as functional and easily locally produced.
In the left corner a protected nest can be seen by the tree. A small concrete cube closed by a lid houses the nest that can be easily explored. The access to the nest takes place through a tube which is essential because in its absence the nest is not recognized as such by the does. It has been observed that two or more does can give birth in the same nest. This is also a problem for industrial systems that propose models in which more does have to share the same space. This is probably an ancestral condition, also known for other species, because more mothers nursing mixed broods allow the survival of the strongest even in conditions of food shortage.
Trees should be planted inside the warren to provide shade and forage. Mulberries are possibly the best trees; their branches have been tested as very appetizing and rich in protein. The sweet small fruits like very much to children as an example of integrated production. Some other examples of profitable integrated productions will be later considered.
In the opposite corner of the warren a small fenced area can be seen that is very important to improve the management. It has been tested as very efficient in models of improved warren. In the area, rabbits can find feed and water and can enter through a small passage. Every fifteen days the passage must be closed in the late afternoon with a small door that can be pushed to enter but, being wider than the passage, cannot allow rabbits to get out again. Then all the rabbit can be easily caught. The does are checked if pregnant and if not they can be mated in the buck cage outside the warren. Empty does are eaten, instead of being maintained while not producing, and weaned kids are brought to the fattening area. Sanitary control is very easy and production is increased. This system with the same structure, but built with other materials, was successfully tested for some years by some Italian breeders. Nevertheless, it was never tested as a part of a project.

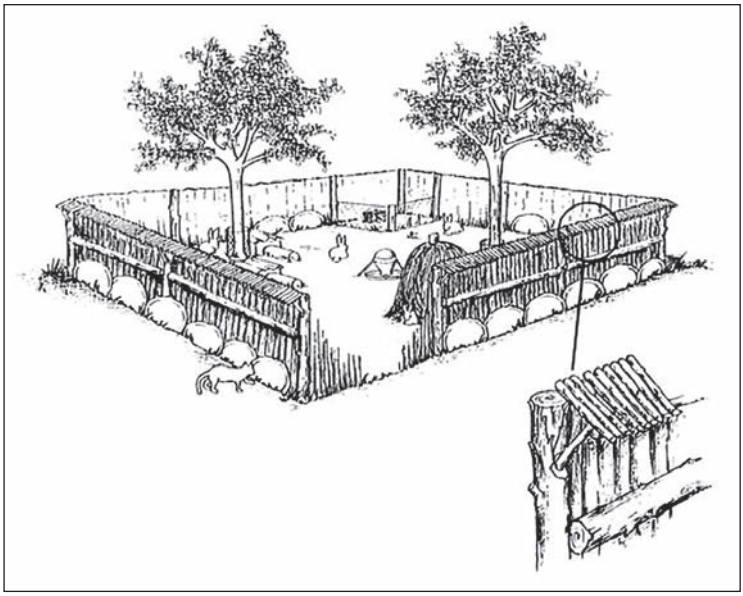

FIGURE 6. A project for a free ranging rabbit colony.

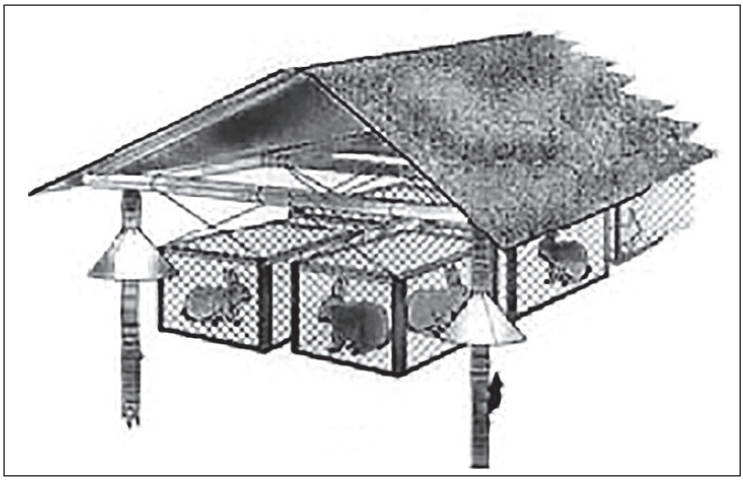

FIGURE 7. A protected fattening area.

FATTENING

While the underground cells, being individual shelters in the open air, avoids any direct or indirect diffusion of infective sicknesses and it is sufficient to isolate any suspected case to maintain a healthy stock, on the contrary it is not similarly easy to care the health condition of fattening rabbits.The actual rule is to keep only three rabbits per cage, so that, if one rabbit is suspected, the whole cage can be immediately removed and isolated. In Figure 7, the drawn represents a possible solution under field conditions. The metal cones are easily produced with the lateral part of recycled tin boxes to protect from any climbing predator as serpents or rats. The cages are hanged individually and easily removed and displaced. In the figure it is not clearly shown, but there should be a passage between the two rows of cages. The roof must be made of straw and metal should absolutely avoided.
However, in case of a metal roof, that is cheaper than a well-done traditional hay roof, any kind of grass or branches must be thrown on the roof to shadow the metal. To underline this, remember that many times I have seen traditional huts with a cheaper metal roof and all people sleeping outside being the inside still too hot when night is coming.
The importance of the presence of trees does not needs to be mentioned to this regard.

NESTS, FEEDERS AND DRINKERS

Variously shaped clay nests have been observed in the different rural family units. The use of readapted pigeons nests or of specifically shaped vases are frequent. They are cheap and common and can be easily cleaned by washing and even disinfected with fire. One case is worth to be remembered.
Trying to understand the importance of rabbit keeping in the economy of the family, I always asked about the main problems related to rabbits. Strangely, once, a woman taking care of the animals was not mentioning the mice that were always said as being able to found a passage, sometimes by gnawing on the wood of the cages, and eat the newborn kits. She denied that it was a problem. At the end, she showed me a small table over which there were some metal boxes provided with holes in the lid. She explained me that they were the nests where the does had delivered and each morning she opened the boxes and brought them to each cage. Immediately the does jumped in the boxes, milked the pups and, when they left after few minutes, she brought again the boxes to the table. There were no chances for mice and this shows that sometimes the consultants have more to learn than to teach!
Drinkers are commonly formed by tin conserve boxes nailed in a corner of the cage This is frequently a problem for kits. In this case, flat containers are used but rabbits jump into them and the water is immediately spoiled. A very simple drinker is shown in the draft of Figure 8.Plastic bottles are easily found everywhere. A hole must be done in the base of the bottle and the base is easily produced with cement or cooked clay. Closing with a finger the hole in the bottom of the bottle, this can be filled. Then, the bottle is closed with its plastic cap and turned upside down; then, the base is adapted and the bottle turned again. The cheap siphon drinker will work very well.

From the same Figure 8 it is easy to understand how to make also a simple, cheap and functional feeder, though in rural areas to feed concentrates is very uncommon. These examples show that it is possible to develop something new working inside the local traditional production systems and it is easy to get successful results using local materials according to traditional technologies. Even something unexpected can happen. In Cameroon, I was involved in a Canadian project where rabbit raising was included among many most important and expensive ones. I could not understand why a big ceremony was to be organized, but notwithstanding, being only invited, I spent my five free from working days in a village. It was then when I succeeded to get made the raffia no-nail cage with movable base working together with a handicapped man who started then to raise rabbits by himself. I worked also with a middle-aged woman who was able to cook for me the clay base of a siphon drinker.

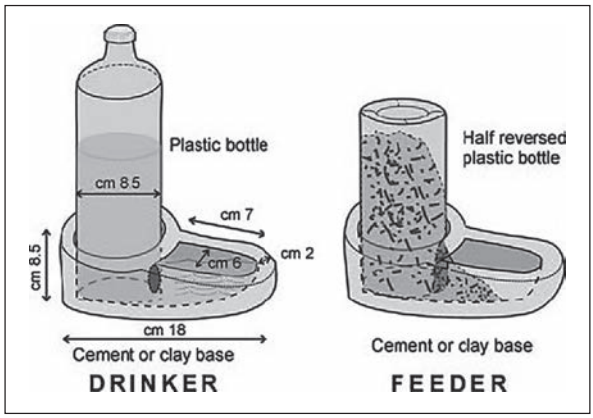

FIGURE 8. Draft of easily built drinker and feeder.

When the local political and tribal authorities had spoken, I was also asked to speak. I was accompanied by the two local people who had worked with me and I showed what we did. The cage was appreciated and especially the drinker when they could see that the water was not pouring out of the clay base. However, I was appreciated when I could say: "I knew what to do, but I did not know how; they knew how to do, but they did not know what. Being each one alone, nothing could be done, but together we succeeded to do it!".

It should look obvious that to import from Europe equipped cages to donate them makes people forever dependent, but teaching them to build what they need makes them independent and free. However, what was more surprising was that I was later informed that both the ones who helped me had begun to sell their cages and drinkers.

THE INTEGRATED SYSTEMS

Very frequently, it is common to find any kind of animals in the yards of rural houses, but this should not be considered as a chance of integration, while only a kind of competition for food can be observed.

The most obvious chance of integration of rabbit keeping is horticulture. All that is not profitable for men can become feed for rabbits and rabbits drops are manure for the plants. This point is of main importance because in many developing countries cattle feces are used only to coat the branches that form the walls of the huts or to make fire in the kitchen. To get a good manure it must be remembered that it is possible and easy to utilize e plastic leaf to shape a container under the cages, both

of does and fatteners, to collect rabbits drops not losing the urine as a rich nitrogen source. When feces cumulate, there is no emission of bad smell and they can remain and ferment on place until a good manure is produced to be utilized when necessary. The model integration on three levels, as shown in Figure 9, is of main importance when the yards are small because it minimizes the need of space. Rabbits are raised in an underground cell system; the unit cucumbers are grown to shadow but any common climbing plant can be used. Pumpkins have been utilized because their wastes are appetized by rabbits; salted seeds are something special for children, moreover they have an efficient anthelmintic effect very important where intestinal worms are a common children sickness; finally, rice and pumpkin are a very popular Italian food which, as I have tested, is much appreciated by people accustomed to eat only white rice.
The ducks under the cages are Muskovy ducks. Coming from South America, these animals have an incredible capability of adaptation and have spread all over Africa not needing any project. They can be commonly seen going around in the villages, mainly in the markets where they eat any kind of vegetal wastes. When rabbits are raised, Muskovy ducks choose always to stay under the rabbit cages as if it was their preferred habitat. They feed on insects or worms grown among the feces and it is nearly fascinating to see how they are able to catch flying insects as a source of protein; then, they also go around grazing to complete their nourishment. In addition, wastes of slaughtered rabbits are very much appetized by ducks. A small number of Muskovy ducks and some pumpkins can be obtained at no cost as an added precious output of a properly integrated rabbit production.
It is also possible to make a passage to allow ducks get out of the yard fence to go around to graze or feed with anything they are able to find. Normally, the system does not need feeding costs and, with possible variants does appear as the best support to the family food supply in poor field conditions. Everything can be done with local materials worked according to traditional technologies, making people free from depending forever on imported means furnished by the international support.

FIGURE 9. Integrated production on three levels.

CONCLUSIONS

To raise rabbits is not easy as raising chickens or goats. Before starting a project, to make a course to teach the know-how is not sufficient. According to a long experience, in Developing Countries it is practically impossible to make e successful rabbit

breeding unless at least one person able to raise rabbits is already living in the area. If he learns and applies something new and profitable, simple imitation by other peoples guaranties the success. Thus, it is better to work together with few clever and interested persons who learn and diffuse the know-howthan to try to teach by words out of the work context.

A long experience has thought that a previous full immersion into the local cultural system is advisable and to work alone with some collaborative local people is better than going as a group of "strangers" donating cages and proposing the use of integrated feed without learning in advance from the market that the production cost of the project must be lower than the market price even in case of auto consume.

Anyway, it should be remembered that alternative open-air rabbit keeping systems are aimed to the rent integration of small farms in the industrialized countries or to food security and some income in developing ones.

Peculiar traits are: small inversion at beginning; slow growth of the unit with the gains if some rabbits, also frequently requested as sires, are sold; growth limited according to available part-time work or to local marketing chances; use of local materials according to local technologies; only open-air units; sanitary control only by management and no needs of pharmacological treatments, mainly antibiotics, that anyway should be forbidden.

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FEED AND MANAGEMENT OF RABBIT PRODUCTION IN EMERGING COUNTRIES

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One of the main controversy regarding the sustainability of animal production is connected with its environmental impact (OECD-FAO, 2021). Theoretically and practically, meat production is more environmentally expensive that the plant production (Van Kernebeek et al., 2016). Indeed, the main laws of the ecology and thermodynamics imply that at every passage from a trophic level to another one (from plants to primary-, secondary- and n-consumers) only about 10% of the energy that was contained in the first level is left to be used by the second one. Thus, the loss of energy caused by the eating of animal instead of plants is an universal property.
In the same time, animals could store in their tissue some nutrients and magnify their bioavailability (vitamins, fatty acids, proteins, minerals etc.) rendering them more accessible for humans. In Table 1 it is evident how rabbit meat is richer in vitamin (D_3 and B_{12}), available iron, long chain PUFA. One of the whole point of animal production remains to convert plant proteins of little or no use to people as food into high-value protein. Rabbits can convert about 20% of the proteins they eat into edible meat similar to what calculated for broiler (23%) and higher than pigs (about 18%) and beef (10%) (Lebas et al., 1999).

Table 1. Main average characteristics of vegetal and animal sources (rabbit meat): importance of bio-magnification.

	Vegetal sources	Rabbit meat
Vitamin D_3	-	+++
Vitamin B_{12}	-	+++
Iron (heme)	-	+++
Polyunsaturated Fatty Acid (PUFA)	++	+
Long Chain PUFA (> 20 C)	-	++
Saturated Fatty Acid	-/+	+++
High quality protein	-/+	+++

Moreover, the organic compounds produced by digestion and excreted into the soil, if not in excess, help to sustain plants upon which animals will feed. This "natural" cycle, which occurs in nature, is far from what happens in standard animal production due to the selection for more productive animals, which enlarges the efficiency of energy retention, the concentration of animals in small areas (i.e. eutrophication, etc.), and intensive rearing techniques, which do not effectively take into account all

the interactions (environment, society, health and welfare of animals) of the productive chain.
Moving on to rabbits, the production and consumption of this species is greatly lowering in developed countries due to several facts related to the rearing system, the change in food habits and the "image" of the rabbit as a domestic animal, which is greatly changed in the last years. However, many of the reasons which render the production of rabbit still interesting are convincing like the excellent qualitative characteristics (high digestibility of meat, low fat content, high level of B_{12} etc.), the high productivity and the low competition with foods available also for human (cereals, soybean and other protein crops) (Prudêncio da Silva et al., 2010).
This last point is highly relevant in developing countries where poultry and rabbits are considered the main species for fulfilling the increasing animal protein demand. Rabbit production is adaptable to the family diet and food preservation techniques available on rural and peri-urban farms. It is highly productive in terms of kg/year/doe thanks to its reproductive behaviour, short gestation and lactation and high prolificacy. The investment is low, the breeder can easily put infrastructure together, and not much space is needed.
Accordingly, rural rabbit farms are a possible answer to the demand for sustainable development projects. For this reason, FAO and other governmental and non-governmental agencies supported rabbit projects in these countries. However, projects had not the expected stimulus effect and many of them regressed or disappeared. The main reasons for these failures concern the lack of local dietary resources available for low-cost diets, the presence of diseases and the breeder knowledge, which may be unfamiliar with this species.
Anyway, the main constraint to the diffusion of rabbit (and poultry) breeding regards the high cost of feed ingredients, such soybean, maize, wheat, and millet that are in competition with human nutrition. The discrepancy between the local supply and the demand for these ingredients is expected to grow in the next future.
Accordingly, alternative feeds locally available should be found mainly if they are non-competitive with human nutrition. In this view, rabbit production could be more sustainable than poultry whose feeding plan more strictly depends on these ingredients. Indeed, the rabbit can utilize diets rich in fibre if compared with other small livestock species because of its digestive system able of use forage. Unfortunately, in the last years the low cost of cereals contributed to reduce the amount of forage in the rabbit diets (<20%) making this production less environmentally sound and sustainable.
Thus, the adoption of diets with high forage content should be further investigated and adopted to reduce the reliance of rabbit diets on cereals and protein crops.
In assessing the environmental impact of animal foods there are several interactive aspects. In monogastric animals, where digestion produces minor emissions of greenhouse gases, the feed is the main factor responsible for environmental impacts, independent of the rearing system (cage and non-cage; conventional and organic).
Therefore, the productive performance, the feed intake, and, consequently, the feed conversion ratio have been identified as highly influencing the environmental impact of this chain. In brief, four main factors affect the environmental sustainability of the animal diet:

- the feed conversion ratio (how much feed is necessary for producing one unit of food);
- the feed ingredients used (i.e., different crops need more or less inputs);
- the cultivation techniques of the crops (i.e., dry crops, use of chemical fertilizers, herbicides and other chemicals);
- the dietary requirements (energy, protein, amino acids, etc.) of the genetic strain to achieve certain performance.

FEED CONVERSION RATIO

Considering the good feed conversion efficiency of high-performance animals, some authors (Leinonen et al., 2012, 2016) found that intensive systems are more sustainable than less intensive ones. On the other hand, other authors showed that the different requirements and feed ingredients of less intensive strain could mitigate this enlargement (Boggia et al., 2010).

FEED INGREDIENTS

According to the Farm to Fork Strategy (European Commission, 2020), food waste generated in the EU represents "about 6% of total EU emissions". This means that we should reduce these emissions.
Based on these studies and reports, the sustainability of animal production (mainly studied in poultry productive chain) is strictly correlated with the nature of feeds and, although genetic selection has the potential to reduce the resources needed for body growth, the need for certain feed ingredients (mainly protein sources) to fulfil animal requirements may limit the path to sustainability.
The use of alternative feed ingredients, such as locally grown protein crops, alternative sources (Dal Bosco et al., 2010), forage, and by products, as a replacement for soybean and cereals can potentially reduce environmental impacts, deforestation, and CO2 emissions.
A relevant aspect of the resources related to feeds and food is the risk of animal competing with humans for high quality feeding sources. The "golden standard" formulation should be based on an increased amount of locally sourced feedstuffs, which must not compete with human food or require transport.

CULTIVATION TECHNIQUES

Conservative agriculture, which implies the use of natural fertilizers and products for controlling weeds, insects, bacteria, and viruses, generally, in terms of the amount and quality of energy inputs, requires less and more-renewable amount of energy (i.e., every t of urea requires about 1 t of fossil fuel). Moreover, different crops (i.e. poly-annual meadows vs annual crops or legumes vs cereals) require different amount of renewable energy (for plowing and fertilize).

DIETARY REQUIREMENT

All the domestic species in western countries have been strongly selected to achieve high performance. These strains are very productive but they require very controlled environmental condition and high quality feed. This is not the case of many of the emerging countries where the local environmental conditions (i.e. hot climates) and the feed are generally poor. So, local breeds or their crossbred have lower productivity but they are more adapted to these harsh productive conditions and, at the same time, they have lower dietary requirement which could be better satisfied with less concentrated and sophisticated feedstuff.

Beside the sustainability issue, the role of fibrous diets on preventing digestive disorders (Xiccato and Trocino, 2020) have been extensively studied but few findings defined correct feeding practices and specific dietary requirements for rabbits. The early access to feed by the milking rabbits is retained having a key role in the assessment of microflora and more stable digestive function (Paes et al., 2020). In turn, the control of microbiota might also have a direct impact on digestive problems around weaning due to the selective barrier and through its role as an immune stimulator and by reducing post-weaning mortality. One promising approach is to manipulate the microbiota of the gut to optimize rabbit health by modifying nutritional components of the feed and by favouring the early intake of solid feed. Combes et al. (2011) suggested that, during the initial colonization stages of the gut, the rabbit microbiota is unstable and undergoes microbial changes until 21-35 days of age; moreover, during the pre-weaning period, the microbiota of the mother can influence and support the stabilization of the intestine. The early administration of dehydrated alfalfa is a promising solution to improve health status by favouring an appropriate digestive microbiota (Mattioli et al., 2019).

According to this view, the present article aims to evaluate possible feed and management strategies for making rabbit production more competitive and sustainable, mainly in emerging countries.

To this purpose, standard and "improved" techniques will be assessed and compared.

1. In particular, the impact of **diets** with low or high forage content will be scrutinized also in the aim of improving the development of digestive system of young rabbits in peri-weaning period besides reducing the mortality during fattening.
2. On the same time, some **reproductive techniques** for improving health and welfare and animal-friendly skills will be assessed.

Diets

Data coming from different experiments and technical reports (**conventional** and **high fibre** feed composition - Table 2) were compared for outlining scenarios. These formulations are average of the feeds used in does and rabbit weaning and fattening. At the same time, empirical comparison with poultry production will be done, underlining the use of competitive and not competitive (for human) ingredients of the diet. All the protein crops and cereals (soybean, sunflower, wheat, corn, etc.) have been classified as competitive ingredients whereas alfa-alfa, other forages and by-products have been considered as not competitive. Mean formulation for broiler chickens

(as average between starter, growing and finisher diets) have been used. Moreover, for comparing rabbit vs chicken production the following feed conversion ratio were considered (2.0 vs 3.0).
Furthermore, starting from the data of Dickerson (1978) partially modified, we calculated the energy cost (separated per competitive or no competitive ingredients) of protein production in the meat.

Table 2. Mean formulation (%) and chemical composition of diet for broiler; conventional and high fibre (HF) diets for rabbits.

	Poultry	Rabbit (conventional)	Rabbit HF
Cereals (corn, wheat, millet, etc.)	60	60	14
Proteic feeds (soybean e.m, sunflower)	30	16	8
Forages (different origin)	-	20	70
Other feedstuffs	8	2	6
Vitamin mineral premix	2	2	2
Chemical composition (%)			
Crude protein	19.2	16.9	16.4
Ether extract	4.5	2.9	2.4
Crude fibre	2.5	15.3	20.2
Ash	9.5	9.3	10.0
Metabolizable energy (kcal/kg)	2.850	2.426	2.410
Competitive ingredients (%)	90	78	22

The comparison of productive performance (done one a farm producing about 200,000 rabbits/year) between conventional and HF rabbit diets showed non significant differences in does performances whereas the fattening rabbits showed the following different outcomes:

1. strong reduction of post weaning mortality (from 10% to 5%);
2. lower growth performance (33 vs 31 g/d);
3. higher conversion index (3.90 vs 4.09);
4. lower production cost (about 15%).

Accordingly, keeping into consideration that these data have been obtained in commercial rabbit farms it could be argued that in less intensive conditions this little difference in growth performance disappeared making the use of HF diets even more sustainable and competitive. Naturally, the diets and the fibre to be used in the different countries should be defined based on the local availability.
When comparing the performance of rabbits with poultry species (broiler, turkey), the rabbit is less efficient to transform the energy of the feed into meat protein (105 vs 85 kcal/g protein, respectively). Rabbits can convert the proteins available in cellulose-rich plants, whereas it is not practical to feed these to chickens - the only species with higher energy and protein efficiency (Lebas et al., 1997). The grains and soybean fed to poultry put them in direct competition with humans for food. For countries with no cereal surpluses, rabbit meat production is thus especially interesting.
When the comparison is done with other herbivores, rabbit is much effective. Cattle or sheep raised for meat production require that most of the energy consumed by the

herd has be used to maintain females, which have a low fertility and prolificacy compared to female rabbits. Rabbit meat is still more advantageous than milking cows (184 kcal/g protein).
Moreover, using the proportion of competitive/non-competitive ingredients used in the diets, rabbit is the most promising species mainly when HF diets are used (Figure 1). Accordingly, rabbit supply chain should promote these peculiar characteristics of the production by favouring the natural physiology of rabbits and the use of high fibre content in the diets.

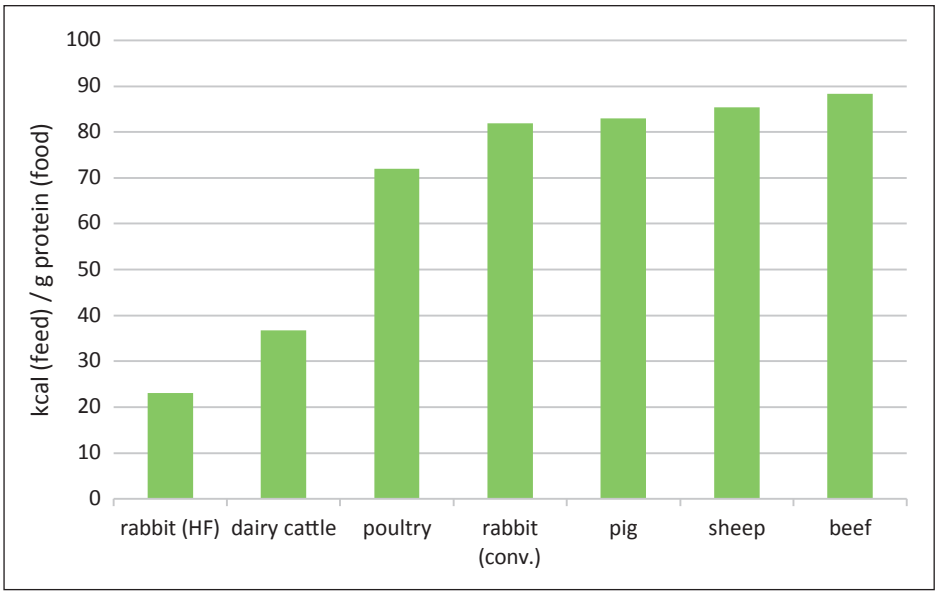

FIGURE 1. Kcal of non competitive feed needs for producing 1 g animal protein.

Rearing techniques
In this subchapter, the main friendly reproductive techniques will be analysed. In particular, **which is the best reproductive rhythm to use in emerging countries?** Naturally the answers are not univocal because many factors interact each other (genetic source, dietary constrain, know-how); however, some key concepts can be advanced. It is widely known that rabbit does could be tentatively inseminated every time after parturition. In the same time, it is also evident that the reproductive performance of does largely depends on their sexual receptivity, which is closely related to the reproductive rhythm adopted (RR). Generally, more intensive RR gives low fertility rate and needs high replacement of does (Castellini et al., 2006). Thus, it is quite evident that in emerging countries the most suitable RR, which does not need oestrus synchronization, would be the post-weaning (PW) rhythm. Indeed, immediately after weaning the non-milking does manifest an oestrus due to the lack of antagonism with prolactin and to their better energy status (Cardinali et al., 2008).

Accordingly, the difference (+21 d) between the longer mating interval (63 d), respect to the standard RR (42 d) is partly recovered by the increase in fertility rate (from 10 to 20% plus). This means about one litter/doe/year less but the does are much more healthy and with a longer reproductive career (+50%). In summary, the PW rhythm determines that the doe in the whole reproductive career can give about 60% more parturitions than a female mated at 42 d (Castellini et al., 2010). Therefore, also the cost of breeding does would be taken into account.

As a last point, **what are the more friendly reproductive techniques to be adopted in these countries? Should artificial insemination (AI) or natural mating be preferred?**

It is not a simple question because this choice depends on several factors. It should be noted that using PW rhythm, the oestrus synchronization became non-necessary and only the ovulation should be induced (i.e. GnRH). GnRH is a non-specific drug very easy to find even in emerging countries. The advantage of AI is that does could be inseminated independently on the mating activity of the buck and in this context more does could be inseminated and controlled by a technical "extension service" which is very advisable.

In conclusion, rabbit production, mainly if utilizing diets rich in fibre, could be more sustainable than other species (poultry) whose feeding plan more strictly depends on these ingredients. Likewise, animal-friendly reproductive techniques could be developed to increase the welfare and the health of does and young rabbits.

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THE TAMAT LAPIN PROJECT - DEVELOPMENT OF THE RABBIT SUPPLY CHAIN AND FAMILY AGRO-ECOLOGY: INITIATIVES TO COMBAT FOOD INSECURITY AND RURAL EXODUS IN BURKINA FASO

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INTRODUCTION AND CREDITS

The LAPIN project idea was developed following a reflection based on the desire to eat a "garlic chicken" at Le Paradis restaurant in Ouagadougou. It is not difficult to find chicken meat in Burkina Faso, more complicated is to find "the poulet-bicyclette", the local free-range chicken, decidedly delicious. Reading the menu, however, the "roast rabbit" attracted my attention. I changed my mind. I called the waiter for the order: rabbit was finished. I remained mouthwatering, and I promised myself to keep looking for it. In the following days, in other restaurants, the result was the same. I got curious and ask my friend Moussa, an old agronomist from Burkina Faso, where I could eat a rabbit.
"*Mossi* eat hare, rabbit is what white people eat!" Lapidary in response, for the culinary tastes of expats. Yet, with this answer, he managed to stimulate my interest in rabbit meat in Burkina Faso even more. The real spark striked at the 1st Burkina Faso Livestock Fair, Salon de l'Élevage-2017. I saw some rabbit cages, and I had an exchange of words with the exhibitor who told me that the MVA virus has almost decimated rabbit farming in the country. I looked then for statistics from the competent Ministry, without any success. I finally managed to meet the then "Minister of the Élevage" who said he was very interested in developing the rabbit sector in Burkina Faso and invited me to look for funding for an experimental project.
This is how the LAPIN project was born. For this reason, in this report, we have not been able to omit general background data on livestock farming in Burkina Faso and to introduce the project with two chapters before analyzing its technical results, its critical aspects but also its development potential.
Tamat project idea is based on a research-development approach thanks to the support of the DSA3 of the University of Perugia, in particular to Prof. Cesare Castellini, whom I thank together with Prof. Francesca Maria Sarti, who have supported Tamat since the conception phase of the project; they have therefore "lent", for the period of two field missions in Burkina Faso, the skills and the spirit of adventure of Dr. Samira Giovannini, a DSA3 doctoral student, who had the patience to write together with me this contribution for the event "Rabbit breeding in emerging countries" scheduled for 22 October 2022.

A project that would not have existed without the drafting skills of the design team of Tamat, coordinated by fellow Patrizia Spada, but especially without the presence in the field of the project leader, Fabiola Bedini, who managed all aspects of the implementation phase and consolidated relations with the local partner Association Manegdbzanga, with which the country-representative of Tamat, Denisa Savulesco, whom I thank, had already experienced collaborations in rural development activities. It was Manegdbzanga, in fact, together with local agronomists, who encouraged the active involvement of small farmers in the pursuit of the set objectives.
Finally, a heartfelt thanks, of course, to the funder of the initiative, the Presidency of the Council of Ministers of the Italian Republic that with the funds of *ottopermille* - Interventions for hunger in the world- has fully supported the financial aspect of the project.

BURKINA FASO BETWEEN FOOD INSECURITY AND FACTORS UNFAVORABLE TO AGRICULTURAL DEVELOPMENT

Burkina Faso is a country in the Sahelian belt of West Africa, with an area of 273,187 km^2. Despite the fact that since 1960, the year of independence, it has experienced a significant economic growth, confirmed over the past 4 years (2016-20) with an annual growth rate of gross domestic product (GDP) always above 5.2% with a peak of 6.7% (Plan National pour le Developpement Economique et Social, 2016-2020), it remains a poor country. It is ranked 183 (2017) - out of a total of 188 countries - in the world's Human Development Index (UNDP, 2014); 40.1% of the population lives below the poverty line (World Bank, 2014), with a life expectancy of 60.8 years. In Burkina Faso poverty is mainly a rural reality, with an incidence on 47.5% of the population; in urban areas it affects 13.6% (Plan National pour le Developpement Economique et Social, 2016-2020). Rural poverty accounts for 92% of total poverty in the country: 9 out of 10 people living below the poverty line live in rural areas.
The **primary sector**, which is fundamental for the country's economy - employing a large part of the labor force, accounting for more than 30% of GDP and accounting for 80% of exports – is still characterized by traditional production techniques and, often, at the limit of subsistence, that generates a market characterized by chronic instability of food prices, accentuated by recurrent famines, speculation of operators and the absence of efficient social and development policies. The most affected population is the most vulnerable (women, children, displaced persons) who depend on the market and/or international aid to meet their food needs. The Burkinabé government has prolonged the implementation of the "National Plan for Economic and Social Development" (PNDES) till the 2025, which contains guidelines for a sustainable socio-economic development of the country. The problems of lack of coordination between the various ministries, the inadequacy of human and technical resources and the "security emergency" are significantly reducing the desired impact.
This scenario promotes **widespread food insecurity**. According to World Bank (2018) data, food insecurity is 13.9% severe and 47.7% moderate. The population below the poverty line is 41.4% while GDP per capita (2019) stands at $786.9. The average income for small farmers (WFP, 2019) is $146. In 2019 only 59% of chil-

dren under 6 months are breastfed exclusively and 17.4% of children aged 6 to 23 months have an acceptable basic diet (Emergency Nutrition Network, 2019). In the same year, only 13.8% of women of child-bearing age had a diversified basic diet in which cereals (98.5%) and legumes (57.2%) appeared; the prevalence of acute malnutrition, chronic malnutrition and underweight was 8%,1%, 25.4% and 17.3%, respectively, in children under 5 and 4% in young women.
Local agro-zootechnical realities are not solving the problem for several reasons among which we can highlight:

- **Agricultural production limited in quantity and quality**: although the level of production is improving, diversification remains limited, while the development of the agro-pastoral sector suffers from the lack of enterprises in the formal private sector (World Bank, 2017). In the most productive areas of the country, intensive crops have contributed to the degradation of soils, already structurally poor and naturally subject to water and wind erosion phenomena. Still predominant, cotton exports account for about 60% of total agricultural exports. Horticulture is mainly carried out with the use of chemical fertilizers, often of low quality, rotation is not practiced extensively and there are few experiences of integration between agriculture, livestock and forestry.
- **Low value added to agricultural production**: the small producers, who are the majority, do not have sufficient skills and tools to increase the value of agricultural production, which, once harvested, must be sold immediately. Few are the agro-food structures that can transform the products or store them efficiently; the result is generating important wastes especially for horticultural products that, due to the lack of the cold chain, are present on the market only during the period of high production (sold at very low prices) and are scarce during the rest of the year. This has a twofold negative effect: i) on producers' incomes, ii) on the quality of the food diet of producers/consumers and their families. 75% of agricultural production is carried out by the families, with low specialization, lack of skills of production and low investment capacity.
- **Insufficient animal productions**: even though livestock production accounts for 30% of primary production and the demand for meat in Burkina Faso is very high, the national supply is insufficient. The country imports white meat from abroad (e.g. Brazil) and red meat from neighboring countries. The main causes of this low productivity are various: use of only local animal breeds - characterized by slow growth rate; significant lack of information/knowledge on modern breeding systems - vaccinations and compliance with health and hygiene rules; lack of adequate nutrition; lack of a genuine supply chain for the marketing and processing of meat and meat products, both in terms of personnel and infrastructure; difficult access to adequate funding for the necessary investments. In other words, 97% of the cattle are still reared in traditional breeding systems (National Cattle Survey -ENC1/2018- December 2021).

To this scenario it must be added the climate change effects - that impact on a territory already endemically affected by advanced processes of desertification, generated by a connection of natural and anthropic factors - which expand the negativity

of the impacts of the other two elements that characterize the systems of agricultural production: soil and plants. Ideally, it is possible to represent Burkina Faso as divided into three macro climatic areas as represented in Figure 1.

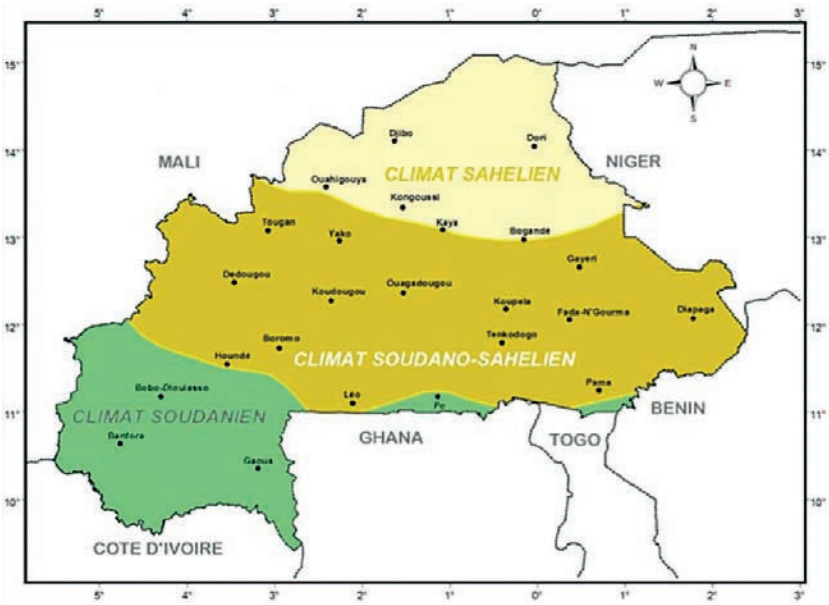

FIGURE 1. Micro climatic areas of Burkina Faso (Ouédraogo, 2012).

These climatic areas can be designated as follows: from the north-east to the south-west of the country there is a "Sahelian climate" with total annual rainfall of less than 300 mm, then a "Sudano Sahelian climate" with rainfall between 300-800 mm/year, ending with the "Sudanese climate" with rainfall ranging from 800 to 1100 mm/year. Below climate data, average thirty years (1991-2021) of the capital Ouagadougou (Table 1).

Table 1: Ouagadougou climate data

Temperature (°C)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dic
Mean	25.1	27.7	31	33.1	32.6	30.2	27.5	26.1	26.9	28.8	28.2	25.6
Mean min	17.7	20	23.1	26.4	27.3	25.6	23.7	22.8	23.1	23.7	20.7	18.3
Mean max	32.9	35.8	38.8	39.6	38.5	35.6	32.2	30.2	31.6	34.5	35.7	33.4
Rainfalls (mm)	0	0	2	13	30	57	128	198	108	33	0	0
Humidity (%)	16%	13%	13%	27%	44%	57%	70%	79%	76%	57%	27%	20%
Days of precipitations	0	0	0	2	5	7	13	16	11	4	0	0
Hours of sun	10.3	10.5	10.8	11.1	11.2	10.4	8.2	7.0	8.6	10.1	10.4	10.3

The first important note concerns the temperature. There have been abnormal high peaks above the mean values, which have immediately manifested their negative effects in the agricultural and livestock sectors.
In horticulture, in the dry season, there has been a greater evaporation of irrigation water, drawn from traditional shallow wells and ponds, which dried at the end of January, not allowing the conclusion of irrigation crop cycles.
In the breeding of chickens, a malfunction of incubators was noted, especially in the months of April and May, when the optimum operating temperature was systematically exceeded. In the same months, in family farms, there was a block of the heat of the does.
Although there has not been a significant decrease, new phenomena should also be recorded in pluviometry. A shortening trend of the "rainy season" was noted. In other words, with the same amount of precipitated water, the "wet period" begins later and ends earlier. For the cultivation of millet, the food-crop par excellence in Burkina Faso, it means a delay in sowing and a possible shortage of water in the physiological moment determining the filling of caryopsis. Moreover, there are more and more cases of torrential rains, with phenomena of heavy rainfall concentrated in a short time and with an important "force". Often associated with wind, these phenomena have caused significant damage to millet and maize crops, leading in some cases to the destruction of crops, especially in the Mossi Plateau. These types of rainfalls limit the infiltration of water into the soil and promote runoff, generating two harmful effects: the reduction of the activity of recharge of underground aquifers and the development of soil erosion phenomena.
Among the nine large groups of soils that characterize Burkina Faso, two are those that represent 2/3 of the total: i) *fluvisols* and *regosols* (26%): young, poorly developed soils on gravel, and in alluvial deposits; ii) *lixisols* and *luvisols* (39%): tropical ferruginous soils poorly leached on sandy, sandy-clayey or sandy-clayey materials. These soils, already structurally fragile, shallow and with poor fertility, undergo the phenomena of water erosion that from an agronomic point of view are manifested in an accentuation of the loss of fertility and a reduction of the cultivable area.
The ongoing changes in the regime of precipitations and temperature, therefore, have negative effects on traditional patterns of agro-zootechnical production: i) increased evapotranspiration, which generates a greater need for moisture for crops; ii) erosion phenomena leading to a demand for the restoration of fertility and physical availability of soils. In short, they require investment of various kinds, a rare commodity in Burkina Faso, as in all Sahelian countries.
To conclude this list of factors that affect the agro-zootechnical development in Burkina Faso it is important to briefly refer to at least two others:

- **Population growth**: the population is estimated at 21,510,181 in 2020, characterized by a 3.1% annual growth rate (World Bank), a total fertility rate (TFR) of 5.4 children per woman and an estimated life expectancy of 56.7 years. The percentage of population from zero to fifteen years is estimated at 47.4% and that under five years to 18.1%. Women account for 51.7% of the total population. **Exemplary** numbers of a young population, constantly evolving with a growth rate that minimizes the positive results of economic growth in the past decade,

by limiting, in this way, the positive effects of the increase in GDP, not allowing a real and considerable reduction of poverty.

- **Security and displaced persons**: in recent years, Burkina Faso has been the subject of numerous Islamist terrorist attacks. In 2021, 2,000 people, most of them civilians, died. All this has generated a **phenomenon** of mass flight from the areas of the north-east of the country, most affected by the phenomenon, which has generated a very high number of displaced people who have moved in a southerly direction especially towards the outskirts of the big centers and in particular the capital Ouagadougou. According to data from the Burkinabé Red Cross, in August 2022, the number of displaced persons came close to 2 millions of people. Official data from the Burkinabé government, at the end of December 2021, showed 1.5 million displaced persons, officially registered. It is clear, therefore, that this situation has severe negative effects on food safety. An example is the estimation of the feed budget - made by the Burkina Faso Government's Food and Nutrition Situation Forecasting Committee (CPSA) - which in its note of 29 March 2022 estimates a production of almost 21 tons of dry matter (TMS) sufficient to meet requirements in normal times. The insecure effect, however, (the concentration of livestock in the reception areas for displaced persons, the unavailability of certain pasture areas) has adversely affected the budget to the point of concluding with an estimate of a negative deficit, at national level, of 50,774 TMS, at least for a period of seven months (November to May).

IN A MARGINAL SETTING FOR RABBIT BREEDING: THE LAPIN PROJECT

The cuniculture has been and remains a marginal activity of the zootechnical sector of Burkina Faso. Animal production in its complex, instead, is an important trade for the economy of the Country. It contributes 14% to the value added of the primary sector and accounts for over 4.1% (Integrated Approach Programme (IAP) on Food Security -May 2021) of GDP, and it is at the 4th place for export products. Modern farms are marginal in the national panorama and are mainly dedicated to poultry breeding. The traditional, extensive breeding, instead, represents 97% of the livestock in Burkina Faso. It can be divided into two macro categories: sedentary and seminomadic. The first is mainly characterized by small animals (poultry), the second by ruminants (44%). The results of the National Livestock Survey (ENC1) 2018 - published by the local Ministry of Agriculture (MARAH) in December 2021 - certifies that most breeders are sedentary (85.3%) and that nomadic forms of farming, traditionally characterizing the Sahelian scenario, are increasingly residual. However, it should be noted that natural pasture remains the main source of feed for ruminants, followed by residues from agricultural harvests, especially cereals. The scenario is confirmed by data on vaccinations: 80% of cattle farmers vaccinate herds that for a good 50% are also dewormed. The ENC1 - which carried out (2018) a survey on the number of traditional livestock farms and a census on the so-called modern farms (2019) - shows a number of breeders of 2,320,438 individuals, or 17.3% of the total population from ten years of age up, and 1,735,550 families who practice breeding,

or 55.9% of families. Moreover, in rural areas 71.7% of families practice traditional breeding and 73.3% of farmers are not literate. The modern farms, on the other hand, are 1,632 of which 1,437 farms (88.1%) of individual owners. This concerns, in the overwhelming majority (97.8%), poultry. The livestock sector in Burkina Faso, excluding poultry, consists of 31% sheep, 31% goats and 28% cattle. The average breeder is the owner of a few animals: in 2018, the average numbers of animals possessed by a breeder of cattle was 9 as well as that of sheep and goats, 6 animals instead was the average number of animals per pig farmers. Also, in 2018, the density of the animal population was estimated, per square kilometer, at about 33 cattle, 39 sheep, 39 goats and 5 pigs. In traditional poultry farms, local breeds account for 77.4% of the total and on average each farmer has 21 animals. Table 2 summarizes the national population by species.
Rabbit production is marginal as a total number of heads, but it has potential for development also in the typology of the so-called "modern companies" that are currently essentially devoted to the poultry and that are characterized by the ability to invest, the application of modern production techniques aimed at the pursuit of objectives set by a defined decision-making center, supported by salaried employees and whose product is addressed to the market, for 50%.

Table 2. Effective number of animals per specie in Burkina Faso (Source: ENC1- December 2021)

Species	Effective number
Cattle	9.156.945
Sheep	10.721.570
Goat	10.623.106
Donkey	1.372.617
Horse	141.003
Pig	1.302.821
Camel	26.874
Rabbit	110.198
Laying hen	281.410
Chicken	155.098
Local chicken	25.581.756
Local guinea fowl	5.474.336
Turkey	141.521
Duck	292.336
Pigeon	1.145.081

The cuniculture could attract private investments and satisfy a need for consumption that has been repeatedly reiterated also by the association of restaurateurs of Ouagadougou who have already successfully proposed the rabbit to consumers but have failed to consolidate the offer for lack of a constant supply of meat. The development of this supply chain could favor a greater presence of women producers reversing a trend that sees men owners, for example, 89.5% of modern poultry farms; mainly the result of productive investment in rural areas of a city class that has earned income

in other activities. This would explain the high percentage (37.4%) of owners who have a high level of education and who, however, have an entrepreneurial approach (only 10% are illiterate). It is not a coincidence that 44.2% of companies are located in the capital Ouagadougou region.

THE PROJECT LAPIN

In this context, Tamat, a civil society organization (OSC) of Perugia, realizes the project "*Development of the rabbit chain and family agro-ecology: initiatives of resilience against food insecurity and rural exodus in Burkina Faso*". Funded by the Presidency of the Council of Ministers, with the funds of the "*ottopermille*", it began in March 2021 and ended in late May 2022. A "research and development" project aimed, on the one hand, at assessing the development possibilities of the rabbit chain in Burkina Faso; on the other, in close contact with new breeders - beneficiaries of the project activities -, to assess the interest, the difficulties and the real possibilities of creating new opportunities for income and for increasing the quality of the diet, mainly for rural families. The design hypothesis is based on the observation that rabbit production in Burkina Faso is not unknown and that consumers, especially in the urban context, appreciate its meat. The problem of stagnation, if not a reduction in national production, can be attributed to economic factors which, of course, are linked to technical ones. On one hand, the costs of breeding do not guarantee an attractive income to the breeder: on the other hand, the forms of practiced breeding are inadequate due to the lack of technical assistance that exposes the farms to potential diseases. The spread and contagion of Hemorrhagic Viral Disease (MEV/RHD) in 2017, which has substantially halved the number of animals across the country, is the most recent example that has greatly reduced the number of breeders. At the present, therefore, there are only small farms located mainly in the central area of the country (Plateau Central, Région Centre).

The project LAPIN starts after the deadly attack of the MEV and settles in the Municipality of Loumbila, about 35,000 inhabitants 20 km northeast of the capital Ouagadougou, where subsistence family farming, fishing and trade are the main activities of the local population, although there are important shortcomings in terms of low productivity, lack of processing and storage facilities, and the absence of modern companies aimed at producing for the market.

The project aims to contribute to the food and nutrition security of the population of Loumbila through the enhancement of cuniculture and the improvement of agricultural production, to promote a significant integration of the diet, with important amounts of animal and vegetable proteins. In order to integrate animal breeding and agricultural activities, the project provides the signing of exchange agreements between the two groups of beneficiaries, which will see farmers supplying the waste of horticultural products to breeders for feeding rabbits, and breeders providing manure to farmers for its use as natural fertilizer.

It involves 400 direct beneficiaries of the village of Tanlargho of the Municipality of Loumbila: 200 from 40 families of farmers and 200 from 40 families of small breeders.

For the start of the breeding activities, the 40 families of small breeders received all the material needed to start the production: cages, one buck and two does, pelleted feed, basic training on modern methods of breeding rabbits, constant technical assistance, veterinary care and access to credit for starting a micro-enterprise. In selecting breeders, priority was given to young people and women, who are normally excluded from ordinary credit channels because of the impossibility of providing collateral. The beneficiaries voluntarily join the Rabbit Breeding Centre of Loumbila realized by LAPIN and finalized: i) the selection, reproduction and sale of rabbits; ii) the production and sale of pellets for rabbits feeding.
An association has been established among the beneficiaries of the project, which has its own management committee that will ensure the future sustainability of the Centre.
The indirect beneficiaries of the project are the local populations of Loumbila and Ouagadougou, which will see improved accessibility (local products at affordable prices), availability (increased production) and product quality thanks mainly to the presence in the project partnership of the Association Manegdbzanga of Loumbila. Founded in 1991, operating in the fields of non-formal education, sustainable rural development and the fight against food insecurity, women's empowerment, the creation of small businesses to promote employment - especially youth. The association consists of 82 local committees operating in 71 different villages between the province of Oubritenga and the province of Kadiogo. To date, there are 1809 active members, of which 1072 are women. Working in the same areas of intervention, the strategic agreement with Tamat was immediate.

EXPECTED RESULTS

Act. 3.1 Selection and technical training on rabbit breeding technique for 40 families of Loumbila breeders

For the project, as reported, 40 families were selected to be beneficiaries of a cage, two does and one buck, feeding complete concentrate for six months and technical support from local agronomists for all the duration of the project and Italian expertise support that was concentrated in two missions. The first mission was focalized on providing the technical training to the local agronomists in charge of the project and to the beneficiaries. The role of the local agronomists in the project was very crucial. The technical training, then, was focused not only on the general knowledge concerning the activity of breeding rabbits, but also on the needs of a local organization and coordination of the activities among the families and the genetic center. With the aim of collecting useful information about the management and the reproductive rhythm of the rabbits, three types of chart have been created and assigned to the local agronomists: one for each breeding female, one for each male and one collective for the litters. The female chart foresees the possibility to insert the information relative to the reproductive doe (breeding of origin, age) and to her performances: mating (date, id male), palpation, kindling (date, number of live births, number of still births, number of adopted, number of withdrawn) and weaning (weaned number,

mean brood weight). The male chart requires the collection of similar information to evaluate its reproductive efficiency. With this operation, an attempt has been made to convey the importance of data collection aimed at the control and optimization of a breeding unit, especially in modern breeding systems where the human labor is essential for the correct management of animals in cages. In addition to the information of the identity of the breeders associated to the identity of the reproductive unit (does and buck), it was decided to monitor the average weight at weaning and the average weight at the end of the cycle before slaughter. All the reproductive animals, during the project were weighted two times by the local agronomists to collect information about the growing and reproductive trend of the local rabbit breed.
The technical training (Figure 2) for the families needed to be characterized by short and practical information, since the subject of the training was completely new for their knowledge. The people from the village didn't have any notion about rabbits. Training lessons concerned: rabbit handling, feeding, reproduction management, correct cage management and the main rabbit diseases.

FIGURE 2. Training lessons with the beneficiaries breeders.

The training lessons were very useful on providing information about the correct technique of breeding rabbits in a controlled environment as the cage. One of the most important topic that was imperative to convey was the importance of maintaining inside the cages good level of hygiene, which is the best tool for the prevention of sanitary problems. All the training was conducted with the support of visual and printed material characterized by clear images showing the good management technique for breeding rabbits.

Act. 3.2 Supply and installation of equipment and raw materials necessary for breeding

The breeding activity started in July 2021, when the cages were delivered to the beneficiaries of the project together with the reproductive rabbits. The cages were located around the housing facilities of the family, not all the beneficiaries were capa-

ble to locate the breeding structure in protected places, so often they were exposed directly to the weather climate condition. The cages were produced by local artisans with wood and metal mesh, following the indication offered by the Italian technical support; the cages were equipped with automated drinkers. The cage model (Figure 3) was chosen between the prototypes available among the local artisan's production, but increased in size in order to provide more surface to the rabbits, which are known to suffer from heat stress. The wood material was preferred among the metal one that absorbs heat and so rise the temperature of the breeding environment. To cope with the wet season, each breeding unit was provided with a large waterproof cloth to protect the cages in case of rain. Even the floor of the cages was designed with wooden rods large enough to ensure a good distribution of the weight of the animal in order to avoid footpad injuries and access routes for pathogens.

FIGURE 3. Example of the cage model used in the project LAPIN.

Every breeding unit also received the equipment for feeding the animals, and a plastic brush for cleaning the cage daily, as suggested by the training. After the delivery of the rabbits, all the animals of each family were recognized with a Figure and an ID code to identify all breeding units uniquely. With this scope, since the rabbits presented high variability in terms of coat color, the assignment of the rabbits has followed a precise objective: rabbits with different fur color were assigned to each family in

order to simplify the technical support activities of the local agronomists and facilitate their communication with the beneficiaries. Since the delivery of all the equipment, all the families received a technical support, both from local agronomist and Italian expertise who followed all the implementation of the breeding and monitored the health status of the animals that arrived very weakened from the transport and previous bad breeding condition. From the day after the first delivery, a few deaths from the reproductive does of the families were observed.

Act. 3.3 Purchase and improvement of breeding reproductive rabbits

The availability of animals in the market of Ouagadougou was lower than the numerical needs of the project, so the animals where distributed to the beneficiaries in different moments. The animals were provided by two different local breeders and were delivered after bad transportation conditions, which affected their welfare. The reproductive does and bucks had different ages and different sizes at arrival. Some animals, even if presenting perfectly formed genitals and symptoms of a reached sexual maturity, seemed to be of lower age and showed an inadequate morphological growth. This could be due to the breed of the rabbit, which has been recognized from Burkinabè rabbit breeders as the "local breed", which might explain the reduced size and low growth trends. In literature, there aren't many information about the morphology and the characteristics of the local rabbit breed of Burkina Faso, which might be the result of crossbreeding of imported breeds. Traoré et al. (2015, 2018) described, on their survey about the cuniculture in Burkina Faso, the existence of variability between the populations of rabbits and fur colors very diversified. Moreover, reproductive rabbits of improved breeds where acquired with the aim of observing their performance in harsh environmental condition and use them to study a program of genetic improvement of the local breed. With this purpose, a genetic selection center was established inside the village, where programmed crossbreeding mating took place.

The "breeds" of rabbits used in the selection center were: females mares sold as "Hyplus", known French commercial hybrid, and bucks belonging to local breed. The goals to achieve in terms of genetic selection were: resistance and adaptability to the conditions of breeding, to rise rabbit productivity, evaluated for does in terms of fertility and number of kindling, number of births and numbers of weaned, and for all animals by weight at weaning and growth rates.

Act. 3.4 Feeding strategies

It is known that feed costs constitute one of the main obstacles to the development of a sustainable rabbit supply chain in harsh environment of developing countries. For this reason, another important goal of the project was to identify alternative feeding sources not in competition with human nutrition. To satisfy the basic nutrition needs, a pellet machine was provided in order to empower the reproductive center to produce the rabbit feed. The intention was to make the village as much as possible independent from the industrial market. A complete pellet formulation was acquired by a local pellet producer and then produced in the village. The principal ingredient used where what was available in local markets around Tanlargho: soy, rice bran, corn, cotton meal, peanut meal, cowpeas and panicum maximum. Many suggestions in

literature have been found about possible nutritional supplement with variety of local vegetal varieties. For this reason, research of the vegetation present in the area of Tanlargho was carried out in order to identify possible alternatives to conventional ingredients. The most represented vegetation grows during the wet season while in the dry one it's more difficult to find proper vegetation. The available vegetation is represented by trees, such as Mango, Karitè, Papaya, and plants, such as Peanut plant, Moringa oleifera. Since around Tanlargho the main trees were Mango trees (*Mangifera Indica*) and in literature it is reported a study on the use of Mango leaves in rabbit nutrition, it was suggested to the beneficiaries to use the leaves as a supplement fodder. Jokthan (2003) in an experiment showed that mango leaves have feeding value as fodder for rabbits; it could represent a feed reserve especially during critical period of feed scarcity in dry season. Some limits on varying feeding in a proper way have been found. To disclose the potential use of some local vegetal varieties more studies on the basic ingredients have to be made, especially in nutritionally terms. The other limit relays behind the impossibility of conducting experimental tests with different diets, which requires a continue follow up in order to assess every possible variation on the weight of the animal, and on its digestive system and health.

PROJECT RESULTS

Results on management of the breeding units

The second mission from the Italian technical support took place in March 2022, with the aim to evaluate the data collected from the local agronomists and to observe the performance of the project activities and the attitude of the families toward the breeding activities. It has to be reminded that rabbit production has never be practiced before by the people from the village, as well as the breeding system confined in cages, which requires labor and skills from the breeder. It is important then to observe the results considering the evident obstacles that have accompanied the development of the project. The results in this article will be described starting to underline the main limits that occurred during the realization of project activities and how that had affected the results.

Previously, it has been reported how crucial was the role of the local agronomists on supporting the families through the project activities, so a lack of information collected during the project made harder to read the findings.

To evaluate reproductive performance of rabbit does, it is essential to collect information about the physiological events that involved the animals, especially if the breeding activities are applied on rural marginal areas as a first time. All the charts entrusted to the agronomists were partially used or misused; of all the information required, just a few data were collected. Picturing and describing every breeding units in detail was unfeasible, but through verbal information collected during the second mission by the Italian technical support, it was possible to reconstruct at least some trends.

Given the lack of explanatory information about the management and performance of rabbits provided by each family, it was difficult to isolate the reasons behind the numerous deaths occurred among the reproductive rabbits of the beneficiaries. Out of

a total of 40 families, just 14 breeding units didn't register any deaths among the reproductive rabbits; in details, other 13 families registered only one death; for 8 families the death of two reproductive rabbits was recorded, for 5 families the deaths of the entire breeding units were listed. As a first reasonable cause, it can't be neglected the health condition in which the first rabbits were delivered during the first mission. High stress levels due to transport, stress levels probably due also to previous breeding condition, had already affected the health of the animals. In fact, important lesions were visible from biting, ulcerative pododermatitis, and physical conditions, not always optimal. In addition, the incidence of deaths among rabbits delivered by another breeder was low. All this may have contributed, together with the new breeding environment and the not excellent management, to cause deaths, at least those that occurred in the two weeks after the delivery. Additional causes may lie behind a bad adaptation of the animals to the breeding condition and to a bad management among some families. It has to be highlighted that after six months, when the grant of free food has ceased, families started to provide alternatives sources of feed without the approval or previous consultations with the technical support. Some of the animals during the project lose weight or were not involved in any reproductive event.

Reproductive results of the families' breeding units

The majority of the families, precisely 25, have not recorded any kindling, but it should be reminded firstly that due to the deaths of the reproducers, time has been lost, also due to the organization of the substitution of the animals, as the latest deliveries were recorded in December. Moreover, all the beneficiaries have never reared any kind of livestock in cage, and they have never seen a rabbit before the project. Thus, more than a few weeks could be necessary to make them efficient on a new breeding technique. In 11 families there was only one kindling listed, in 4 families 2 kindling and in 1 single family 4 kindling.
Table 3 below summarizes the total number of animals counted as the total number of rabbits involved in the project, including those in the breeding center.

Table 3. Total number of rabbits for each category

Total number of rabbits	245
Total number of living rabbits	174
Total number of reproductive rabbits	115
Total number of rabbits born among the families' breeding units	29
Total number of rabbits born in the center	30
Total number of dead rabbits (registered)	66
Unknown status	5

In addition, it was reported the premature death of many litters that very often occurred before weaning: litters that died just after kindling, or were abandoned from the doe; all of these episodes were reported only verbally. This condition can be caused by various factors, in this section the observed errors of managerial type will be reported.
First, a misuse of nests has been observed both in the beneficiaries families and in the selection center. Already during the first mission the importance of inserting and

opening the nest exclusively on the 28th day from the mating has been underlined; in this way the rabbit has access to the nest only in the days when, physiologically approaching kindling, will feel the instinct to prepare it. This precaution allows initially to provide a nest always properly cleaned. In addition, it is possible to manage better the rabbit even from the point of view of the lactation. It has been explained, in fact, during the training, that adopting a technique called "controlled lactation" could help does to maintain contained stress levels and therefore to have the opportunity to express its maternal abilities. Nevertheless, in all families, there has been a persistent misuse of the nest with consequences of a decrease in hygiene and an increase on kindling carried out outside the proper structure.
In this context, the importance of adapting the reproductive structure to the reference environment must be highlighted. A metal nest, as the once distributed to the families, is more easily washable. Its hygiene is very important to avoid bacterial proliferation and the onset of pathogens; however, this is a material that overheats when exposed to the sun. Since the brood has the need of a high and controlled temperature (30-35°C maximum) a not sheltered nest exposed to the external temperatures, that reach even 45°C, involves an excessive rise in the internal temperature resulting in suffering and death of the brood itself. At this point, it was clear that the families that better located the cage in a proper place protected from the sun exposure have encountered fewer problems with the management of the brood and the nest. During the dry season, temperature reaches very high values, thus increasing the labor of beneficiaries who must have regard on choosing the right time during the day in which perform the activities that involved animals manipulation, such as mating. For example, difficulties have been reported on mating the reproductive rabbits that was due to managerial mistakes. To begin with the choice of the right moment for coupling, confusion was found between beneficiaries and agronomists on the interpretation of the doe's heat. Very often, it has been referred that the buck was moved in the female cages and left there all day long, or that the breeder used to organize the coupling in the middle of the day and during the hottest hours. This incorrect management has affected the reproductive performance of the reproductive rabbits and, together with the high temperatures, the success of reproductive operations was altered. It has to be reminded that given the scarcity of data, it was not possible to describe physiological or fertility problems, not having the certainty that the beneficiaries have been carrying out mating performed correctly or due to the harsh environment

Results of the breeding center

As regards the center, the same problems have been observed: the access to the nest and the non-application of scheduled lactation. In this case, however, kindlings have been registered. It has to be reminded that in the center specialized does were used, that might explain yet a different result. Moreover, it should also be noted that more assistance has probably been offered by local agronomists at the center, which has led to a better success of the activities. In Table 4, the reproductive data registered during the breeding activity of the breeding center are summarized, with a total of 8 does of which 5 in activity.

Table 4. Reproductive performance of the breeding does of the center

ID	Number of kindling	Average offspring	Living offspring	Time of activities
1	2	5	3	July 2021-March 2022
2	3	8,6	16	July 2021-March 2022
3	1	2	0	July 2021-March 2022
4	2	3	2	July 2021-March 2022
5	2	4,5	9	July 2021-March 2022

The above data have been verified by crosschecking the information collected by the agronomists during the monitoring visits to the center and the data collected during the second mission of the Italian technical support. As already described, charts provided to the agronomists have not been used in an appropriate way and there are inconsistencies between the data recorded on registers kept at the center and the data transcribed by the agronomists in Excel which lacks in particular with regard to the number of kindling events. Therefore, the assessments described below referred only to certain data that have been verified and for which a certain reliability has been found.
It should be noted that the other three does died for unclear causes. It has been hypothesized impaired previous health conditions, high levels of stress or incorrect administration of drugs (vaccines and pesticides) used on animals.
As for the breeding males, these have both been registered, however for the moment, only the one male of local breed, good size (weight 2.390 g) and with agouti coat, has been used for the couplings.
The evaluation of the breeding does can be made through the observation of the litters where F1 is the product of the crossing between Hyplus does and local breed. In fact, it was possible to observe a promising result about the growth rate, established by the evaluation of the typical age weight of the F1 litters, which, as expected, were more precocious than what had been reported by the breeder who sold the local breed. There are no explicit references in the literature about the productive trends of the local breed. The breeder had reported that the desired slaughter weight (1.5 kg live weight) was reached by the local breed in 5-6 months, whereas in the case of F1 litters an average weight equal to 1.559 g was achieved in just 4.5 months.

Results of the breeding units: focus on the materials used (cages)

As previously reported, the cages bought for the project were chosen from those produced in Ouagadougou by local artisans. The choice fell on a typology built with wood, for which specific measures were provided in order to obtain more spacious boxes, therefore limiting the possibility of overcrowding of the cages. The chosen material, wood, since is a bad conductor of heat, showed itself as a good material in an arid environment, although it is not equally robust and solid if compared to structures constructed in iron or steel that are also easier to wash. In fact, with this choice it was given priority to the temperature problem and to a very common health problem in modern farms, equipped with cages made with just steel, injuries to the plantar bearings. The type chosen was also provided with a semi-automatic drinking system that through pacifiers and a tank above the cage brought water by gravity to all the boxes.
The nests have been built separated from the cage module, with the possibility of hooking the same and closing it through the installation of a sliding opening. Theo-

retically, the modules, chosen in photos from those produced on site, seemed to respond to the main needs related to the livestock and climate context. The problem arose during the first mission when the cages were delivered. They had been built in a hurry, the wood had not undergone any treatment but rather was of very low quality, the measures of width and depth have been reversed and the drinking system has never really worked. All the families, including the center, have had to dispose of it as it lost a lot of water and risked to damage the wood of the cages. Therefore, both in the center and in families breeding units, feed and water were provided with terracotta bowls that, however, required more maintenance (they must be filled daily) and were less accessible to bunnies. Many modules were also damaged during transport, many families were forced to arrange a support that, placed in the center of the cage, could help the very thin support bases to offer support to the weight of the entire structure. Another important aspect to underline regards the hygiene concept which is very important for the management of a breeding system in cage. In the center, good level of hygiene was observed, but as already reported, in this structure the support of the local agronomists was more present. The trend observed with the second mission showed a good level of hygiene and caring attitude by families to improve animal condition. In 20 families' breeding units a good management was observed starting from the choice of the location of the cage, the presence of all the materials necessary for the breeding (drinker, boxes for feeding pellets), implementations of sun shelters to offer major protection from the sun as shown in Figure 4.

FIGURE 4. Example of a well located and equipped cage.

For the rest the families, a worst scenario was observed: bad location of the cage, dirty boxes, lack of sun shelters, lack of breeding materials such as drinker and feeding bowls; very often even the structure of the cage itself appeared compromised (Figure 5). It has to be highlighted that these results are in line with what observed in households' units: it was possible to observe a wide difference on hygiene and living habits among the families. The worst cages conditions belonged to the families whose houses showed higher level of decay and poverty. Nevertheless, promising results were observed in a good number of families, that gives a glimpse of the potential of rabbit production even in marginal contexts. A young breeder with his family, for example, before the end of the project, purchased from the only one family that abandoned the breeding activities their cage and the rabbits. The young breeder showed good attitude with the breeding activities and saw a great potential on rabbit breeding to ensure food and income to his family. Very impressive was the example of another breeding unit conducted by a women breeder, who incorporated the cage with the animals in the core of the housing unit, the only part sheltered from the sun, where also the family used to eat and rest, showing the great care that she reserved to the animals. Another young breeder, a woman, during the technical support activities showed with proud her breeding unit and her healthy animals. She was one of the family who followed the suggestion about use Mango's leaves as alternative fodder for rabbits. She didn't observe any reproductive problem or concern.

FIGURE 5. Example of a cage lacking of equipment and with no sun shelters.

Results: feeding strategies and genetic improvement of local breed

The lack of collected data from the breeding units among the families and the genetic center affected the results of some of the main goals of the project. Limits has been observed on the practical application of researches and trials to try alternatives feed sources. The importance of providing to the supply chain a feeding base not in competition with human nutrition and locally available, it's what can make the project really sustainable. However, in this phase, the objective resulted impossible to apply. The suggestion of providing Mango's leaves as alternative fodder wasn't followed; just a couple of families tried to vary the rabbit feeding. In those families, good weight and growth trends were observed; anyway, these results can't provide a reliable response due to the low number of families involved and further investigation need to be done in order to support the sustainability of the rabbit supply chain. Moreover, after the end of the supply of feeding - by the project - to the families, these started to give to the rabbits everything they have. In most cases, the "alternative" source of feed was not appropriate for rabbits (fibrous waste from maize processing, local vegetal species not detected, etc.).

Again, the lack of information showed some limits on the study of the local rabbit breed, which needs to be better understood in order to promote a genetic selection functional to support the animals cope with harsh environment and to enhance the production itself. Even this objective, the genetic progress, needs to be develop with the aim of obtaining a productive chain with a reliable and sustainable production. The F1 animals already obtained and the acceptable results in terms of growing trends observed underline the importance of implementing through research and development measures to ensure important results. A transfer of skills and knowledge only, represents a limit in the sustainability of the project itself: new strategies have to be identified, new solutions need to be discovered starting from LAPIN's results. All the project activities shall be calibrated and adjusted to the environment and to the context of breeding.

CONCLUSION

LAPIN constitutes an ambitious project that aimed to ensure food security through rabbits breeding to people living in marginal areas of developing countries. The project, even facing several obstacles, showed the potential of creating a local rabbit supply chain even in a harsh environment. The main problems to consider in these contests regard: the adverse climate, especially during the dry season; the rearing system that takes place in a cage and requires labor and skills from the breeders; and, finally, the local supply of raw materials for rabbits feeding. High temperatures affect certainly rabbit welfare, affecting also their feeding capacity. The goal of genetic improvement requires time and demands a mix of planned activities of research and development. The local breed needs to be studied in order to disclose its potential in coping with extreme weather condition. The same approach needs to be applied on researching alternative food sources not in competition with human nutrition and locally available. This last issue represents the key to enhance the sustainability of the

rabbit supply chain in Tanlargho, which still depends on an external source for producing the pelleted feed.
As already reported, many families showed a promising attitude towards the breeding activities and demonstrated to believe in the project. Some families already sold a few heads of rabbits and one of them implemented the breeding unit with the purchase of another cage and other reproductive rabbits. Very impressing was the commitment that some young beneficiaries demonstrated, first of all guaranteeing - during all the project - good level of hygiene and taking care of the animals with great cure. The realization of the genetic center and the results observed underline the potential and the feasibility of a rabbit supply chain implemented with the genetic selection improvement of the local breed. Even the interest in purchasing the meat produced from the breeders of Tanlargho, shown by an organization of local restaurants, reveals the concrete possibility of the development of a rewardable value chain of rabbit meat. Constraints on the development of sustainable rabbit production needs to be solved in order to identify an efficient prototype to replicate across the continent so that smallholders can benefit, mostly by enhancing food security and income generation. LAPIN offered important insights and results on which to discuss, through which is possible to identify an operational model where include the follow:

i. a commitment among researchers to focus on *in situ* research related to the development of sustainable rabbit production chains, with a particular attention to the needs and possibilities of small farmers;
ii. the enhancement of the use of documentation among the local beneficiaries, as a tool capable to trace every event and information involving animal health and performance;
iii. to be sure to provide always technical assistance to ensure a continuous improvement of knowledge and skills of local breeders, necessary for proper management of rabbit breeding;
iv. to promote and develop an independent local supply chain with all the tools required to produce and provide all the materials necessary for the breeding activities;
v. to consolidate the concept that making network with other breeders from the same village is a fundamental condition to ensure the strength of the supply chain;
vi. to establish local or regional collaboration with other commercial realities to ensure the role of the local chain and its economical sustainability in the future.

In order to guarantee the success of all of these goals is imperative to provide a long-term agenda of activities, time is needed to ensure all the rings of the chain. Rabbit meat production represents a real opportunity to improve the life of families who live in marginal areas of developing countries, where agriculture and animal production are the only tools capable to enforce rural economic development and so fight the poverty.

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THE PROJECT PRIMA – LAGMED "IMPROVEMENT OF PREVENTING ACTIONS TO EMERGING LAGOVIRUSES IN THE MEDITERRANEAN BASIN: DEVELOPMENT AND OPTIMIZATION OF METHODOLOGIES FOR PATHOGEN DETECTION AND CONTROL

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INTRODUCTION

A host can survive without its viruses, but viruses cannot survive without a host. Therefore, even the most pathogenic viruses, which cause serious and fatal diseases, take care of the host over time, in order not to commit a sort of "suicide" by adopting an adaptation strategy which usually implies a reduction of the virulence. However, before the virus becomes less pathogenic, especially if it is 'new' to the host, and the host population builds up its defensive "herd immunity", the spread of the virus can cause enormous damage, especially when the virus encounters many hosts living together in close contact, a situation typical of farmed animals.
Unfortunately for the rabbit and its breeders, already severely affected by the spread of myxovirus in the 1950s, around 1980 it was dramatically hit and affected by a new virus, certainly among the worst existing animal viruses ever described. In fact, this virus, called Rabbit Haemorrhagic Disease Virus (RHDV), causes deadly necrotizing hepatitis, and has an enormous capacity to spread among rabbits, almost destroying rabbit farms within few days. The only good news for rabbits and breeders is that there are very efficient vaccines that can consistently reduce RHDV replication in rabbits and thus avoid the disease (RHD). Proper use of vaccination not only protects rabbits from death, but also greatly limits the spread of RHDV in the environment.
However, the wild rabbits, which are impossible to vaccinate, are an infinite reservoir of RHDV, allowing the virus to maintain a relatively high overall contamination level in the environment. As it is impossible to eradicate RHD from wildlife, an accurate and efficient epidemiological surveillance is the only means of keeping the spread of the RHDV under control and limiting the damage to breeders and pet rabbit owners as much as possible. Therefore, as Covid's experience in humans shows, the ability to control the diffusion of RHDV depends on each country's capacity to set up an effective surveillance system and, at the same time, to maintain a direct and positive collaboration with breeders and breeders' associations.
The first pillars of the globalisation of both scientific knowledge and surveillance/control tools for viral diseases are international governmental organisations such as the World Organisation for Animal Health - WOAH (from 1924 to 2022 called Office International des Epizooties OIE) and the Food and Agriculture Organisation (FAO) whose missions are, respectively, '*…to improve animal health globally, thus*

ensuring a better future for all' and '*to create a world without hunger and poverty*'. Indeed, the possibility to control viral diseases derives essentially from the level of knowledge we have on the different, but closely interlinked, disciplines involved: virology, immunology, epidemiology, and vaccinology, and last, but certainly not least, the hygiene of livestock and livestock production. Clearly, the only way to increase the level of knowledge about RHD and its viral agent is to increase the quality and quantity of scientific data by planning specific research projects, which are then effectively conducted giving relevant outputs.

Following such philosophy, a group of research Institutes, which have been involved in RHDV research for years, decided to submit one research proposal to the PRIMA organisation. The PRIMA Foundation is a non-profit organisation with a spirit of public service, responsible for all management, administrative, support, monitoring and supervisory activities necessary for the implementation of the PRIMA Programme, i.e. financing projects that contribute to the sustainable use of natural resources, economic growth and stability in the Mediterranean Area.

The three-year project (*Improvement of preventive actions to emerging LAGoviruses in the MEDiterranean basin* – LAGMED) was finally approved in 2018 with a total PRIMA budget of € 816,587. The project involves 9 teams of researchers from Algeria, France, Italy, Portugal, Spain and Tunisia. Italy is represented by the WOAH RHD Reference Laboratory, located at the Istituto Zooprofilattico della Lombardia ed Emilia-Romagna since 1994. The funding of the project for the Italian partner is € 97,253, of which € 53,015 come from the Ministry of University and Research (MUR) and the remaining is co-founded by IZSLER.

The main research areas and objectives into which the LAGMED project is divided are presented below, each introduced by a brief review of the main knowledge already acquired and available. Nevertheless, before that, we also report a brief historical and technical summary on RHDV and its impact on rabbit populations and livestock activity.

EMERGENCE AND OVER TIME EVOLUTION OF RHDV

Suddenly, in fall 1986, some breeders in Franciacorta area, close to Brescia (north Italy) turned off the lights in the sheds where hundreds of healthy rabbits were resting, finding 50% of them dead with nosebleeds the next morning. It took two years to discover that the 'killer' of rabbits was not an intoxication, but an infectious disease caused by a previously unknown virus belonging to the Caliciviridae family. At the same time, news from a scientific congress revealed that the same disease had been identified in China at least two years earlier. The disease was named Rabbit Haemorrhagic Disease (RHD), in relation to the main clinic signs and, accordingly, RHDV, its aetiological agent. Looking for the possible origin of RHDV, it was almost immediately realised that RHD was surprisingly similar in the course and lesions to a disease of European hares, called European brown hare syndrome (EBHS), firstly described some years before in North Europe, which aetiology was at that time not yet defined. It was therefore quite easy for us to define that EBHS was a viral disease

but, despite the similarity between RHD and EBHS, genomic, antigenic and experimental disease reproduction studies showed that the two viral agents (RHDV and EBHSV) are distinct, even if correlated. Later, these viruses were identified using genomic approaches and were all grouped in the genus Lagovirus within the family Caliciviridae. Indeed, early sero-epidemiological studies in farmed and wild rabbits, as well as in hares, suggested that together with the pathogenic RHDV and EBHSV also non-pathogenic related lagoviruses were existing and widely diffused in these lagomorph species.

RHD spread rapidly throughout Europe, Asia and Oceania, practically in all regions where the European rabbit was present in large populations. Interestingly, occasional cases of RHD have also been found in Americas since 2000, demonstrating the high spreading capacity of RHDV but also the need for the virus to become endemic of large populations of rabbits belonging to the sole species (*Oryctolagus cuniculus*) considered susceptible at that time.

Looking at the OIE/WOAH reports (WHAIS systems) it is possible to get a quite approximative distribution of the disease in the world (Table 1). In fact, the compulsory notification from affected countries to OIE/WOAH has not been always done and there are some countries where the presence of the disease could be stated only on the base of scientific publications. In addition to those reported cases which originated spontaneously in farmed, domestic, laboratory and wild rabbits, we should remember that the diseases is largely present in Oceania (both Australia and New Zealand) since RHDV initially and then RHDVa and RHDV2 have been intentionally released with the sole scope to reduce the populations of rabbits which, being invasive species introduced by humans in the mid 18th century, are in those countries considered a real pest for the huge damage they cause to natural environments and to agriculture production.

Table 1. Cases of RHD reported to OIE from 2005 to 2022 in four continents

Continent	*Years*	*Country*	*Cases (n)*	*Type*
Africa	2005-2009 2014-2016 2018-1019	Tunisia, Libya Tunisia, Benin, Cote D'Ivoire Tunisia	79 29 9	not typed not typed RHDV2
Asia	2005-2019	China, Cyprus, Israel, Palestine, Korea, Japan	2.210	tot typed, RHDV2
Europe	2005-2020	Hungary, Italy, Romania, Russia, Slovenia, Switzerland, Luxemburg, Greece, Sweden, Germany, France, Ireland, Ukraine, Spain, UK, Poland, Denmark, Belgium, Norway, Netherlands, Finland	1.042	not typed, RHD, RHDV2
Americas	2005 2008 2010-2011 2016 2018 2019-2022	Cuba, Uruguay, USA USA Cuba, USA, Canada Canada Canada, USA Cuba, USA, Mexico	130 1 4 2 17 669	not typed not typed not typed not typed RHD, RHDV2, RHDV2

During its spread, the RHDV virus caused dramatic economic losses in farmed rabbits and ecological and biodiversity damage to some countries, such as Spain, where rabbits are crucial links in the food chain of other wild animals (e.g. Iberian lynx, Bonelli's eagle, etc). However, thanks to the commercialisation of effective vaccines against RHD starting around 1991-92, the occurrence of RHD cases and the severity of economic losses rapidly decreased in domestic farmed rabbits. To note that all those vaccines were inactivated ones produced starting from the livers of experimentally infected rabbits, containing high amount of virions, since RHDV does not grow *in vitro* systems.

But the RHD story took a new turn around 2010, when a new pathogenic lagovirus related to RHDV, but with a different genetic and antigenic profile, called RHDV2, was identified in France. Importantly, vaccines against RHDV were poorly able to protect rabbits from RHD due to RHDV2 infections, so new vaccines against RHDV2 had to be produced. It took some time before a commercial vaccine was available and this once again caused severe losses to rabbit breeding.

The spread of RHDV2 across continents was very rapid and its peculiar characteristics, including i) its ability to cause RHD even in several species of hares and in other wild lagomorphs (e.g. *Lepus* sp, and *Sylvilagus* sp.) and ii) to induce high mortality levels also in young animals (even 1-2 weeks old), allowed RHDV2 to become endemic even in North America (Table 1).

Epidemiological data indicated that during its spread, RHDV2 totally replaced RHDV in the field. Several vaccines against RHDV2 have been commercially available for a few years now and thus RHD is again under mostly control in farmed rabbits. Indeed, some of them are now produced by using a biotechnological approach, thus avoiding the use of experimental infections of live rabbits for vaccine production (Table 2).

Of course, as RHDV2 is endemic in wild animals, eradication of RHD is a goal that is difficult to achieve, and it is easy to predict that the use of vaccines will be the only tool to keep RHD under control in the future.

Table 2. Main RHDV2 Vaccines in the European market (approved by EMA) and type of vaccines produced for RHD and available in the past and/or nowadays and/or in the next future

Type of vaccine	Commercial name	Produced by	# antigen(s)	Adjuvant	On the market	Main properties
Inactivated traditional vaccine produced with the livers of infected rabbits	Cylap	Zoetis	Monovalent RHD	Mineral oil	No more	- Onset of immunity: about 7 days p.v. - Duration of immunity: 12 months - Suspension time: 0 days
	Mevax	IZO	Monovalent RHD	Aluminium hydroxide	No more	
	Mevax 2	IZO	Bivalent RHDV + RHDVa	Mineral oil	No more	
	Dercunimix	Merial	Bivalent, combined Mixo+RHD	No	No more	
	Lapinject	Ceva	Monovalent RHD	Mineral oil	No more	
	Filavac VHD KC+V	Filavie – France	Bivalent RHDV + RHDV2	Aluminium hydroxide	Yes	- Onset of immunity: about 7 days p.v. - Duration of immunity: 12 months - Suspension time: 0 days
	Eravac RHDV2	Hipra – Spain	Monovalent RHDV2	Mineral oil	Yes	
Live recombinant myxoma-vectored RHD viruses	Nobivac Myxo-RHD PLUS	Intervet International - MSD	Trivalent RHDV+ RHDV2 and Myxomatosis	No	Yes	- Onset of immunity: about 2-3 weeks p.v. - High efficacy (protection >90%) - Duration of immunity vs RHD with a single dose about one year
VLPs recombinant baculoviruses grown in pupae of Lepidoptera	Fatrovax RHD	Fatro S.p.A - Italy	Bivalent vaccine RHDV + RHDV2	No	Not yet	- Onset of immunity: about 7 days p.v. - High efficacy (protection >90%) - Duration of immunity vs RHD with a single dose about one year

OBJECTIVES OF THE PRIMA-LAGMED PROJECT

According to what is reported in the project proposal, five main objectives, further divided in specific objectives, were set with the aim "to increase interdisciplinary scientific and technical knowledge on the epidemiological characteristics of RHD and its aetiological agent, the rabbit haemorrhagic disease virus (RHDV), and contribute to the development of effective preventive actions, capable to reduce the socio-economic impact of future outbreaks or of the emergence of new genotypes of unknown origin, especially for African countries of the Mediterranean basin, where rabbits have been promoted for poverty reduction programmes due to the low investment and early benefits, and subsistence on renewable resources for feeding, housing and general management".

EPIDEMIOLOGY AND SURVEILLANCE

Distribution of susceptible species (Portugal, Spain, France, Italy, Tunisia, Algeria)

"With this objective we intend to determine hotspots of outbreaks and identify susceptible leporid species (rabbits and hares), particularly in North Africa. This information will be obtained through ongoing collaborations or projects; hunting and farmers associations; regional authorities; producers associations/integrated companies especially in Algeria and Tunisia."

What we know today

This objective is especially relevant in relation to the rapid and devastating spread of RHDV2. Indeed, in autumn 2011, we found RHDV2 in Sardinian rabbits but, surprisingly, also in several Sardinian hares (*Lepus capensis mediterraneus*) in distinct areas of the island. Subsequently, RHDV2 was identified in other hare species in Europe (*Lepus europaeus, Lepus timidus*, *Lepus corsicanus*, *Lepus timidus* and, during the recent spread of RHDV2 in North America, RHD cases were also found in indigenous hares and *Sylvilagus* species (Table 3). In addition, recent work, yet to be confirmed, suggests that RHDV2 may also infect some micro-mammal species.

Overall, these results indicate that the host spectrum of RHDV2 is much broader than that of RHDV, which is practically limited only to the European rabbit. This difference between RHDV and RHDV2 is certainly one of the main reasons for their different impact in the field. However, it must be stressed that the European rabbit remains the primary host. Indeed, epidemiological data indicate that RHDV2 cases in hares are generally closely linked to relevant outbreaks in rabbits where populations of both species live in sympatry. This suggests that other lagomorph species are less susceptible to RHDV2 than rabbits, i.e. that a high level of RHDV2 contamination in the field is required to cause RHD.

Table 3. Susceptibility of main lagomorph species to virulent lagoviruses

Species	Where	RHDV	RHDV2	EBHSV
European rabbit *(Oryctolagus cuniculus)*	Europe, Americas Asia, Oceania, Africa	pos	pos	neg
Sardinian hare (*Lepus capensis)*	Italy	neg?	pos	neg?
Italian hare *(Lepus corsicanus)*	Italy	neg?	pos	pos
Brown hare *(Lepus europaeus)*	Europe	neg	pos	pos
Mountain hare *(Lepus timidus)*	Europe	neg?	pos	pos
Broom hare *(Lepus castroviejoi)*	Spain	neg?	neg?	neg?
Iberian hare *(Lepus granatensis)*	Spain, Portugal	pos*	neg?	pos
Eastern cottontail *(Sylvilagus floridanus)*	North America	neg	pos	pos
Antelope jackrabbit (*Lepus alleni)*	North America	neg?	pos	neg?
Black-tailed jackrabbit (*Lepus californicus)*	North America	neg?	pos	neg?
Desert cottontail (*Sylvilagus audubonii)*	North America	neg?	pos	neg?
Mountain cottontail (*Sylvilagus nuttallii*)	North America	neg?	pos	neg?

pos: susceptibility proved by detection of natural cases or by experimental reproduction; *neg*: no susceptibility demonstrated by absence of natural cases and by experimental reproduction; *neg?*: no natural cases observed and diagnosed, but not experimentally verified. *just a single case described in the '90.

Current extent of disease

"The scope is to diagnose and identify pathogenic and non-pathogenic lagoviruses on samples collected in the Mediterranean area by using both ELISA and PCR-based approaches and, additionally, to perform a serological surveillance to monitor circulation of RHD and establish the percentage of exposed animals. These analyses will provide data on geographical variations regarding RHD prevalence, which could be relevant to adopt adequate control measures in the Mediterranean basin."

What we know today

Starting from the fact that the presence and distribution of pathogenic and non-pathogenic lagoviruses is well known and described especially in those countries that have an important rabbit industry (Italy, France, Spain and Portugal), we had the opportunity to better define the incidence of both RHDV and RHDV2 in North African countries. To note that, according to WOAH reports, RHD in Africa has been reported since 2005 in some countries (Tunisia, Libya, Benin, Cote d'Ivoire, Ghana, Senegal, Nigeria).

Leporid samples (both organs and sera) from Portugal, Spain, France, Italy, Algeria, and Tunisia were tested for the presence of lagoviruses, and it has been proposed to set up a biobank for storage of these samples. Complete genome sequencing was conducted for a few selected strains; the sequences were shared between partners and, when possible, submitted to public databases (e.g., GenBank). Analyses on the geographical variations regarding RHD prevalence, which could be relevant to adopt adequate control measures in the Mediterranean basin, are still being conducted.

OPTIMISATION AND VALIDATION OF TECHNICAL TOOLS FOR BETTER PREVENTION AND CONTROL OF RHDV

Improved lagovirus detection, genotyping and antigenic typing

"Different research groups use different diagnostic tools to detect the presence of lagoviruses. In this objective we propose to standardise such procedures in order to increase the efficiency of detection and strain typing of circulating viruses. Patterns of disease transmission based on selected Single Nucleotide Polymorphisms (SNPs) that distinguish different populations of GI.2 will be also analysed. Moreover, in order to obtain the antigenic profile of the GI.2 isolates, we will use a panel of anti-GI.2 MAbs produced by partner IZSLER, but new MAbs will also be produced due to antigenic variation between strains from different geographic areas. The knowledge generated will improve our understanding on viral emergence and spread and will contribute to better control the disease."

What we know today

The ability to correctly diagnose a disease is of paramount importance in the context of the surveillance system. Fortunately, RHD diagnosis and classification of the causative agent (RHDV or RHDV2) are very simple and can be performed using various methods, such as ELISAs based on specific monoclonal antibodies or PCR methods that specifically detect the genome. This is because RHD is an acute hepatitis caused by RHDV, which, after infection, replicates in hepatocytes killing a large proportion of them, thus blocking liver functions, and causing the rabbit's death. As SARS-Cov-2 taught us, in order to control the disease at the population level, it is important to understand the evolution of the virus, i.e. to be able to characterise viral isolates both antigenically and genetically: in other words, to be able to identify viral variants over time and correlate them with the clinical and epidemiological data collected by the surveillance system. From this point of view, our knowledge of the evolution of RHDVs is still partial and should be improved by using both monoclonal antibody panels capable of detecting antigenic variations and a genomic approach capable of rapidly identifying genetic mutations. Indeed, it must be remembered that lagoviruses, such as SARS-Cov-2, are RNA viruses with a high possibility of genetic and phenotypic variations. It should be noted that, especially following the spread of RHDV2, several studies have demonstrated the occurrence of RNA recombination between lagoviruses (pathogenic or not) with the generation of new variants characterised by a capsid protein originating from one virus and the non-structural protein part (NSP - e.g. helicase or RNA polymerase...) originating from a second lagovirus. These studies are also very important for the development of vaccines with a high protection efficiency against RHD.

Validation of serological methods for detection of antibodies against circulating RHDV strains

"In this objective, we expect to assess and validate the potential of novel assays in detecting current circulating lagovirus strains in the Mediterranean basin. The specificity and sensitivity of such assays will be estimated for viruses circulating in the different geographical regions. The establishment of new serological immunoassays

and their validation will pass through a comparison with already available tests such as those described by OIE Manual and used as gold standard. Furthermore, to get insight into the antibody response elicited by different viral strains, isotype serology (IgG, IgM and IgA) will be also extended to other leporids, in particular, IgA detection in different hare species using new MAbs recently produced".

What we know today

With regard to indirect (serological) diagnosis, we have already developed several highly specific and sensitive ELISAs, both for the detection of total Ig and for individual isotypes (IgG, IgM and IgA). Following a specific training we are planning to make the serum panel available to the other partners in the near future. The antigenic typing will further contribute to the selection of this panel reference of sera for immunoassays validation. Furthermore, to get insight into the antibody response elicited by different viral strains, MAbs anti rabbit IgA isotype are being tested for their ability to recognize IgA of other lagomorphs.

ANALYSES OF RHDV-HOST INTERACTIONS; INDUCTION AND REGULATION OF IMMUNE RESPONSES

Innate immune response

"Although it is known that the antibody response (humoral immunity) is important in the protection against RHD, other mechanisms of immunity might also play a relevant role. Among them, elevated innate immune competence has a relevant role in protection, in particular for the induction of cross-protection, as has been recently demonstrated in infections with an Australian non-pathogenic lagovirus strain. Innate immune response has been reported, among other possible explanations, as potentially relevant for the resistance to classical RHDV (GI.1) infection of young animals in contrast to adults. We propose to analyse parameters of the innate immune response induced by different GI.2 strains since this response has been shown to be relevant also for vaccine design. The serum profile of cytokines elicited after infection will be determined from blood samples recovered periodically from rabbits experimentally inoculated with GI.2 strains."

What we know today

As written above, humoral immunity is the rabbit's first and main defence against RHD. Therefore, the study of the innate immune response is an interesting scientific objective but less relevant from a practical point of view. Indeed, there are several aspects to be investigated in this area. The first is: when RHDV infects young rabbits (less than 7-8 weeks old) there is no sign of disease, but specific antibodies are produced, whereas when it infects an adult rabbit, it causes its death within hours? Actually, RHDV in juveniles behaves in the same way as non-pathogenic lagoviruses, which, however, are also non-pathogenic in adults. There are some data indicating that this innate resistance to RHD in young could be due to the action of the innate immune system. To support that, there is the evidence that by inducing immunosuppression in young rabbits by treatment with methylprednisolone acetate (MPA) and

then challenging them with RHDV, the young rabbits die of RHD as adults. The susceptibility of young rabbits to RHDV becomes even more interesting in the case of RHDV2. In this case, infected juveniles (even 1-2 weeks old) also develop RHD as in adults. One recent study of liver transcripts from adult and young rabbits showed that kittens infected with RHDV displayed an increased level of expression of multiple genes encoding components of the innate immune response compared with adult rabbits. In contrast, the same genes were downregulated in kittens during RHDV2infection.

Adaptive immune response

"Adaptive immunity is critical for resistance against RHDV. While most RHDV immunity studies have focused on humoral immune responses, very few studies have gathered information on cell- mediated immunity, especially T-cells. To gain insight on the adaptive immune response against RHDV2 (GI.2) we will characterise the T-cell response to homologous and heterologous RHDV capsid proteins, following VLP and/or virus particle inactivated immunisation. We will evaluate the production of T-cell effector cytokines such as IFNγ (by ELISPOT) and proliferation of RHDV specific T-cells after in vitro re-stimulation with VLPs or recombinant polypeptides of VP60 domains (S, P1 and P2). Eventually, T-cell epitopes will be identified using overlapping synthetic peptides. On the other hand, and given the role of antibody response in protection, the kinetics of induction of serum and mucosal antibodies (IgM, IgG and IgA) elicited in immunised rabbits will be studied."

What we know today

Why is the humoral immune system (i.e. antibodies) the main defence system of rabbits against RHD? For all lagoviruses (pathogenic or not) the first site of replication i.e. the gateway into the body is at the mucosal level along the digestive system and most probably the intestinal cells. While non-pathogenic lagoviruses are unable to replicate in any cells other than the intestinal ones, RHDVs, via the portal vein, reach the liver where they replicate rapidly, causing necrosis of liver cells. Therefore, RHDV must reach the liver via the blood in order to replicate there, and consequently interacts directly with antibodies along the way. Several experiments have shown that even very low levels of specific anti-RHDV antibodies in the blood bind and block the virus, preventing its replication in the liver and thus protecting the animal from RHD.

Rabbits may have antibodies against RHDVs in the blood due to four different mechanisms. Of these two are natural a) in the case of infection, if one individual survives RHD, its systemic immune system is triggered, and the antibodies produced (IgG) remain for years; b) as maternal antibodies, transferred directly from the mother's blood during gestation, in the form of IgG up to 6-7 weeks of age depending on the mother's titre. Of course, in this case the immune system is not triggered and therefore the animal is exposed to the risk of disease a few weeks after birth. The other two mechanisms are artificial: c) in the case of vaccination, the rabbit develops antibodies in about a week that remain at a detectable level for several months. The immune system is triggered, and memory can be increased after months with a second vaccination (booster) to keep at high values the level of specific anti-RHDVs IgG;

d) by passive protection with the injection of 1-2 ml of a hyperimmune anti-RHDVs rabbit serum into a vein. Actually, this is identical to maternal antibodies, but protection lasts no longer than 1-2 weeks after inoculation.
In addition to systemic/humoral immunity, i.e. essentially, the level of IgG in the rabbit's blood, there is also mucosal immunity consisting in the presence of secretory antibodies, the sIgA, that are produced in a large amount in association with mucosal membranes of the body.
Mucosal immunity is governed by different rules and follows different activation inputs than systemic immunity, simply because it is called upon to do a different and specific job: to act as a sentinel at the body-environment interface, populated by millions of bacteria, viruses and food-borne macromolecules.
Among the differences between the two systems is the fact that sIgA remains in the mucosa for few weeks only, and thus, also considering that inactivated vaccines administered via parenteral route do not induce sIgA production, the protection from mucosal RHDVs infection is limited to a short period after infection, either the first or a reinfection. Interestingly, the presence of IgA is a marker of recent RHDVs infection, which is clinically undetectable if the rabbit was already seropositive for RHDVs.

Development of vaccines

"Current commercially available vaccines are based on inactivated infectious viruses. Due to the lack of a cell culture system for efficient virus propagation, such vaccines are obtained by amplifying the virus directly in the host species, i.e. in rabbits. The absence of heterologous protection (e.g. GI.1-4 vs. GI.2 and vice-versa) joined to welfare and biosecurity concerns, justify the search of new alternatives for vaccine production. We will explore the immunogenicity and protection conferred by different vaccine candidates (recombinant VLPs from RHDV of different genotypes (GI.1-4), against homologous and heterologous strains)."

What we know today

Today, several vaccines against RHDV and RHDV2 are available on the market (Table 2). All are based on the virus capsid with the classic calicivirus structure, consisting of the assembly of 90 subunits each containing two VP60 proteins.
The first differences among vaccines concern the methods for obtaining the immunogen, i.e. the viral capsid. Since RHDVs do not replicate in cell culture, the basic and first method to obtain the virus, still used today by some manufacturers, consists of infecting a large group of rabbits and harvesting the liver of those affected by RHD within 72 hours of infection. In these vaccines, the virus is inactivated with formalin, and then adjuvated either with aluminium hydroxide or an oil/water emulsion.
Vaccine registered by EMA and commercially available in Europe are monovalent for the sole RHDV2 (e.g. ERAVAC®), that could be considered almost the unique serotype nowadays present in all countries, or bivalent containing both RHDV and RHDV2 serotypes (e.g. FILAVAC®). Where permitted, e.g. this is the case of Italy, with the liver of rabbits dead during an outbreak, which are obviously rich in virions, it is also possible to prepare an autovaccine by using the same procedure of produc-

tion of traditional vaccines (inactivation + adjuvant), which, following the law, may be then used only in particular circumstances.
Recently, two new biotechnology vaccines have been registered: the RHDV or RHDV2 VP60 gene has been inserted into the genome of a vaccine strain of myxomatosis virus, which, when inoculated into the rabbit, replicates, also producing RHDV VP60. Today, a trivalent vaccine based on this method is available against myxomatosis and RHD caused by RHDV or RHDV2 (Nobivac Myxo-RHD PLUS®). A new bivalent vaccine against RHDV and RHDV2, in which the viral capsid is expressed in the form of virus-like particles from a baculovirus growing on the pupae of Lepidoptera, has been approved by EMA and it should be soon available on the market (Fatrovax RHD®). Of course, these vaccines do not need the inactivation step, and Nobivac Myxo-RHD PLUS® does not even need an adjuvant, whereas Fatrovax RHD® uses aluminium hydroxide.

The main characteristics of the four vaccines are the followings:

a) they efficiently protect rabbits from RHD due to RHDV2 and RHDV except Eravac that is only for RHDV2;
b) they induce RHD protection starting from about one-week post vaccination, except Nobivac Plus, that needs about 2-3 weeks;
c) according to the producers, all vaccine induces antibodies with a single vaccination that persist for about one year.

A few thoughts on the use of the vaccine and possible improvements:

a) RHD cases due to RHDV (actually the RHDVa subtype) have been reported very rarely in recent years. This indicates that RHDV2 may have completely replaced RHDV/RHDVa in the field. Based on this observation, the use of vaccines containing RHDV could be avoided. However, while the rabbit population has probably achieved substantial herd immunity for RHDV2, this is certainly lower or event almost disappeared in some populations for RHDV, and therefore it cannot be ruled out that in the future RHDV may partially re-emerge causing severe RHD epidemics. For this reason, the RHD surveillance system must remain alert.
b) Ideally, the first vaccination should be performed on seronegative rabbits. In fact, the aim of the first vaccination is to specifically stimulate the cellular immune system (B cells and T cells) to produce antibodies against RHDV and memory B cells. If anti-RHDV antibodies (either due to active immunisation or as maternal passive antibodies) are circulating in the blood, the virions contained in the vaccine are, more or less depending on the amount of antibodies, precipitated by them to form immunocomplexes, and pushed towards clearance, thus diminishing/abolishing the vaccine efficacy. Consequently, as emphasised above, vaccination should be performed when the maternal antibodies (IgG anti RHDV) are no longer circulating, i.e. between 3-8 weeks after birth depending on the mother's titre (if vaccinated, of course). When using Nobivac Plus, attention must be paid not only to the antibody titre for RHDV2 and RHD, but also to that for Myxoma virus, since the expression of RHDVs particles is closely linked to the replication of the vaccine Myxoma virus. Therefore, the presence of anti-myxo antibodies can hinder or prevent myxoma virus replication by causing a phenomenon known as interference.

c) Vaccine is normally used to prevent RHD within a rabbit herd. However, in relation to specific cases, the vaccine could be used in a herd with an active RHD outbreak to limit losses and reduce mortality level. Usually, RHD outbreaks affect unvaccinated herds (or only unvaccinated fattening rabbits) for 7-14 days, causing the death of most rabbits. However, especially in the case of large farms with several premises, the spread of the virus may be slowed down and therefore the use of the vaccine (which takes 5-7 days to start its action) may help to reduce mortality. Consequently, vaccination could be considered one of the emergency measures to be apply in case of RHD outbreaks.

d) To date, little attention has been paid to the RHDV2 strains used to prepare the vaccines, all of which were isolated between 2011 and 2013. In fact, in the course of its evolution, which probably began in 2008-9, RHDV2 has changed some phenotypical characters, likely as results of genomic mutations. For instance, the first isolates around 2011 were not very virulent (max 30% mortality), but those isolated later, around 2104-15, showed a high level of pathogenicity like that of RHDV (80-90% of mortality). Using a monoclonal antibody (MAb) panel, we have shown that several antigenic variants have appeared and are circulating in the field. To date, we do not know the biological characteristics of these variants and do not know whether some of them are more infectious or can challenge vaccine-induced protection. We mentioned above that a few levels of specific antibodies can slow down virus replication and thus allow the adaptive immune system to prevent RHD, and this is probably the reason for the success of all the vaccines in use today. However, considering the continuous evolution of RHDV2, the use of the "best" vaccine, in terms of homology with the strains circulating in the field and thus of level of protection, should be a goal to avoid facilitating the emergence of new variants with an antigenic profile so different from the ones now used in the vaccines. In fact, in such case a new RHDV serotype could eventually originate and render the vaccines used today almost useless.

BIOSECURITY MEASURES, CONTROL AND PREVENTION STRATEGY

Definition of biosecurity measures, control and prevention strategy

"To prevent the entry and the persistence of lagoviruses in rabbitries, we propose to test defensive and offensive sanitary measures; perform virus detection and serological characterisation of rabbits for rabbit production systems, along with a systematic monitoring of virus circulation in the faeces and cages, before and after cleaning disinfection; due to their role in virus dissemination, we will perform virus detection in passive/indirect vectors taking advantage of planned sampling".

Intervention plans

"Based on the intervention plan already set up and employed in European countries for controlling RHD outbreaks, a specific intervention plan to prevent and/or control ongoing outbreaks will be set up to be used particularly in African countries. The

L'immunité vaccinale dure: 8 à 12 mois.

Plan de vaccination chez les reproducteurs

- 1ère vaccination à 50-60 jours d'âge
- 2ème vaccination après 4-6 mois
- re-vaccination tous les 6 mois du cheptel reproducteur

Compte tenu de la courte durée de vie des lapins pour la viande (environ 70 à 80 jours), ils ne sont généralement pas vaccinés, sauf dans des situations de risque élevé et pendant une épidémie.

Pourquoi est-il nécessaire d'intervenir immédiatement ?

Le virus est très résistant, maintient son pouvoir infectieux à basse température et peut provoquer des maladies même avec de petites doses infectieuses. La contagion entre les animaux peut être directe (malade-saine) et indirecte par contact avec des carcasses infectées, ingestion d'aliments ou d'eau contaminés, vecteurs passifs à la fois inanimés tels que véhicules, ustensiles et équipements (cages et outils), et animés (autres animaux, moustiques, humains).

Une intervention immédiate empêche une propagation massive de la maladie à la fois au sein de la ferme en réduisant l'infection et en évitant sa dissémination territoriale vers d'autres unités de la même zone ou connectées le long de la chaîne d'approvisionnement.

Comment intervenir en cas de maladie ?

Mesures immédiates

- notification des foyers aux autorités compétentes
- élimination des animaux infectés ou suspects
- stockage et élimination contrôlés des carcasses
- enregistrement quotidien des données de mortalité, pour chaque catégorie ce production
- vaccination d'urgence réalisée sur tous les animaux

Mesures d'hygiène et de désinfection

- désinfection des environnements et des structures, des véhicules, des outils et des équipements (par exemple les cages) avec des produits virulicides spécifiques pour chaque matériau et surface
- si le type de structure le permet, effectuer un vide sanitaire

Mouvements

- blocage des mouvements entrants (par exemple introduction d'animaux reproducteurs)
- interdiction de mouvement des animaux à l'exception des mouvements pour envoi « contraignant » à l'abattoir et avec transport exclusif du groupe sur des véhicules lavés et désinfectés avant le chargement
- l'abattage des groupements « sous contrôle /surveillance sanitaire » est effectué à la fin du cycle d'abattage
- interdiction de sortir des aliments, des outils, des objets ou d'autres matériaux suspectés de contamination
- autoriser l'entrée et la sortie de l'entreprise de véhicules uniquement après avoir désinfecté les roues et la partie sous le véhicule
- enregistrement des véhicules et des personnes autorisées dans le registre approprié d'entrée et de sortie de l'entreprise
- envoi de carcasses à éliminer avec des moyens « scellés »

Vaccination

La vaccination d'urgence est réalisée sur tous les membres de la population (élevage + engraissement) avec les recommandations suivantes :

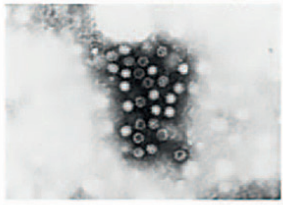
- chez les animaux reproducteurs, il doit être répété 4 mois après la première opération puis tous les 6 mois
- les lapins d'engraissement sont vaccinés au sevrage (35-40 jours) mais il est nécessaire de maintenir un groupe d'animaux sentinelles non vaccinés dans chaque lot de sevrés vaccinés
- suite à une épidémie, pour déterminer son extinction, il est utile de vérifier le taux de mortalité, d'examiner virologiquement les reproducteurs mourants et de contrôler les lapins «sentinelles» non vaccinés avec ces méthodes sérologiques pour vérifier l'absence de circulation virale
- après l'extinction d'un foyer, il est conseillé de vacciner au moins trois / quatre cycles d'engraissement en gardant toujours un groupe sentinelle non vacciné à soumettre à un suivi sérologique

Qui sont les « acteurs » du contrôle ?

Les vétérinaires des services vétérinaires, en profession libérale et les éleveurs doivent utiliser le Mode Opératoire qui définit les procédures à adopter en cas d'épidémie de RHD afin de faciliter les interventions visant à résoudre et contenir les flambées de maladie.

LAG MED

RABBIT HAEMORRHAGIC DISEASE (RHD)



Éditorial et images :

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PRIMA

Quelle est cette maladie ?

Il s'agit d'une maladie virale très répandue et contagieuse causée par un virus de la famille des Caliciviridae, le genre lagovirus. On connaît aujourd'hui au moins trois souches distinctes du virus RHD: le virus RHDV «classique» et sa variante RHDVa et le nouveau sérotype RHDV2, apparu pour la première fois en 2010 en France. Si les deux premiers reconnaissent le lapin européen (*Oryctolagus cuniculus*) comme seule espèce sensible, le RHDV2 est également capable d'infecter certaines espèces de lièvres (*Lepus, europoeus, L. capensis, L. timidus* et *L. corsicanus*).

Le virus a une résistance environnementale élevée, reste contagieux pendant longtemps à l'extérieur de l'animal, maintient son pouvoir infectieux à basse température et peut provoquer des maladies même avec de petites doses infectieuses. Il a donc besoin d'agents inactivants puissants pour être neutralisé.

Les infections entre animaux peuvent être directes (animaux malades - animaux saines) et indirectes (contact avec des carcasses infectées, ingestion d'aliments ou d'eau contaminés, vecteurs passifs inanimés tels que véhicules, ustensiles et équipements (cages et outils), ou animées (autres animaux, moustiques, homme). Les lapins domestiques et sauvages de tous âges peuvent être infectés. Chez les animaux infectés par le RHDV / RHDVa la maladie ne survient que dans les troupeaux et les juvéniles de plus de 40 à 50 jours, tandis que le RHDV2 est capable de provoquer la maladie même chez les très jeunes animaux (10 à 15 jours).

Comment reconnaître RHD ?

La RHD peut être suspectée à la ferme (diagnostic présomptif) en fonction de la tendance, de la morbidité et de la mortalité, des symptômes et des blessures, mais la certitude (diagnostic confirmatif), est obtenue en laboratoire grâce à des tests spécifiques pour l'identification et la caractérisation du virus.

Quelles sont les principales lésions ?

Différentes évolutions de la maladie sont reconnues

Forme hyperaiguë et aiguë

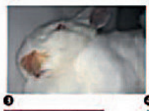
Typique de l'apparition des épizooties et de la première introduction dans une ferme libre où la vaccination était pratiquée :

- morbidité et mortalité élevées (jusqu'à 80%)
- décès en 12 à 36 h après l'apparition de la fièvre (> 40 ° C) ou en 36 à 48 h suite à une infection
- cans les formes hyperaiguës pas de symptômes apparents ou, dans les formes aiguës, cyanose des muqueuses, signes nerveux et signes respiratoires à l'agonie
- présence de saignements nasaux ❶ et vaginaux
- foie augmenté de volume jaune brunâtre avec une texture lobulaire clairement évidente ❷❸
- hypertrophie de la rate ❹
- les hémorragies se propagent à tous les organes ❺❻

Forme subaiguë ou chronique

- elle peut affecter un nombre limité de lapins (5-10%):
- jaunisse sévère et généralisée plus évidente dans la graisse sous-cutanée, l'intima des vaisseaux, les muqueuses explorables et la peau de l'oreillette ❼
- perte de poids et léthargie
- décès tardif (5-15 jours) d'un trouble hépatique

❶ ❷



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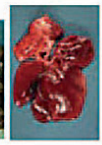

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Quels sont les tests de laboratoire ?

Tests virologiques: détection du virus dans le foie et la rate d'animaux symptomatiques, utiles pour vérifier la présence du virus et définir ses caractéristiques (variant et sérotype). Les méthodes possibles sont l'ELISA, la RT-PCR, Western Blot, l'hémagglutination (HA) avec des globules rouges humains de type 0, la microscopie électronique (ME), l'histologie et l'immunohistochimie.

Tests sérologiques: diverses méthodes ELISA sont disponibles, utiles pour évaluer les titres d'anticorps dans le sang, à la fois pour évaluer l'efficacité de la vaccination et à des fins de diagnostic avec une éventuelle différenciation des anticorps anti-RHDV1 et RHDV2 ainsi que des sous-classes d'anticorps.

Comment la RHD est-elle évitée ?

Les mesures efficaces de contrôle de la RHD, qui peuvent être mises en œuvre dans les exploitations rurales et intensives, prévoient l'application de normes de biosécurité (nettoyage et désinfection précs, contrôle des mouvements, contrôle sanitaire des animaux introduits, enquêtes sur les causes de décès, registre de mortalité quotidienne) et le respect en temps opportun des plans de vaccination.

L'immunité induite par la vaccination est protectrice après 4 à 7 jours p.v. Par conséquent, la vaccination peut également être utilisée comme une intervention d'urgence lors de l'apparition d'un épidémie, en particulier contre des sujets jamais immunisés auparavant (par exemple des animaux d'engraissement).

FIGURE 1. RHDV brochure translated in French.

measures will be tailored to local conditions by adapting those already reported in the documents available for the EU countries."

What we did till today

Disease surveillance, preventive measures and control are the main strategies to reduce the incidence and minimize the impact of RHDV outbreaks. Biosecurity measures are of uppermost importance to prevent and control occurring outbreaks, and they should be improved everywhere, especially in high density farmed areas but also in African countries where industrial rabbit farming is not yet fully developed. Indeed, effective measures contribute not only to the prevention, but also to the avoidance of emergency measures. Nevertheless, intervention strategies in case of outbreaks should be well defined to reduce the impact of the disease and to prevent widespread diffusion of the virus.

Due to the lack of knowledge about the disease in the African countries, we adapted and updated a brochure/leaf note on RHD that was being distributed to Italian farmers. It has been originally prepared in Italian and was translated to French (Figure 1) and Arabic for being used by local farmers in North African countries. The brochure has also been translated to English, Portuguese and Spanish to improve dissemination. In addition to those brochures, we contributed to the preparation of the "Protocol for lagomorphs' samples collection and storage" and the "Lagomorphs' samples collection sheets" for wild and farmed animals, respectively.

Considering that the major goals to be pursued within this objective were: 1) to identify the most adequate and efficient biosecurity measures and prevention strategies to prevent the disease and 2) to define the strategies of intervention during an outbreak to reduce and limit the diffusion of the disease, then we prepared two main documents to be disseminated and utilized in participating countries.

The first document, "BIOSECURITY MEASURES AND RABBIT MANAGEMENT" includes both the *General Requirements for all Farming Systems* - i.e. the detailed requirements concerning the different aspects of rabbit farming (enclosures, buildings and equipment, requirements requested for breeder, inspections, management, drinking and feeding, lighting, reproduction, weaning, handling and transport, changes of physical appearance, emergency killing, sanitary procedures) - and the indications regarding the *Technical and Structural Management of Farms, Biosafety Measures, and Health Programme* - i.e. the structural requirements of farms, the management rules, the methods for cleaning and disinfection, control and biosafety measures - and finally the preventive treatments and direct prophylaxis. Such foreseen measures of biosecurity, as well as disinfection, cleaning, pest control, could be properly tailored to local conditions by adapting those reported in this document.

In the second document, entitled "SPECIFIC INTERVENTION PLAN TO PREVENT AND/OR CONTROL RHD OUTBREAKS IN THE FIELD AND IN RABBIT PRODUCTION SYSTEMS", the intervention plan already set up and employed in Italy for controlling RHD outbreaks has been reviewed and adapted for being used in any farming condition. The text is completed by two flux diagram indicating responsibilities and competence of different people involved in the management of the outbreaks.

MEDITERRANEAN NETWORKING ACTIVITIES AND TECHNOLOGY TRANSFER

Meetings

"In addition to the ordinary annual meeting with all the consortium participants, other meetings/workshops will be held in order to disseminate results and advise stakeholders, and identify synergies and gaps not covered by other projects from different areas."

What we did till today

The coordinator and the partners of LAGMED have elaborated a comprehensive plan for dissemination and exploitation of results and activities, both at the international and national level. This plan ensures a coherent strategy that takes into account each partner's interests and role. According to the strategy outlined in the Communication and Dissemination Plan, some communication tools were created:

– LAGMED website, which can be found at: https://lagmed.eu/
– LAGMED Twitter account, which can be found at: https://twitter.com/lagmed_
– A dedicated page on the website of the coordinating institute (CIBIO). The institute of https://cibio.up.pt/en/projects/lagmed-improvement-of-preventive-actions-to-emerging-lagoviruses-in-the-mediterranean-basin-development-and-optimisation-of-methodologies-for-pathogen-detection-and-control/
– A dedicated page on the website of the Italian PRIMA projects http://www.primaitaly.it/wp-content/uploads/2019/05/190429_PRI_booklet_bandi18_exe_2_LR-min.pdf

Communication and dissemination of the main results of the project have been made in numerous media, including press releases, news in specialized websites, radio interview and oral presentations of the LAGMED results during national and international conferences (e.g. 6th World Lagomorph Conference, Montpellier 2022)
At the moment, the publication of scientific manuscripts includes the following papers:

1. Abrantes J, Lopes AM. A review on the methods used for the detection and diagnosis of rabbit hemorrhagic disease virus (RHDV). Microorganisms. 2021; 9(5):972. doi:10.3390/microorganisms9050972. https://www.mdpi.com/2076-2607/9/5/972
2. Abrantes J, Droillard C, Lopes AM, Lemaitre E, Lucas P, Blanchard Y, Marchandeau S, Esteves PJ, Le Gall-Reculé G. Recombination at the emergence of the pathogenic rabbit haemorrhagic disease virus *Lagovirus europaeus*/GI.2. Scientific Reports. 2020; 10(1):14502. doi:10.1038/s41598-020-71303-4. https://www.nature.com/articles/s41598-020-71303-4
3. Rouco C, Abrantes J, Delibes-Mateos M. Lessons from viruses that affect lagomorphs. Science. 2020; 369(6502):386. doi:10.1126/science.abd2599. https://www.science.org/doi/abs/10.1126/science.abd2599

Training

"We expect to provide training on diagnosis and technology and disease management capabilities, and to promote the mobility of research workers (PhD students, technicians, etc) among the partners, particularly partners in North Africa. Training of stakeholders will be also encouraged".

What we did till today

On November 2019, we organized and held a workshop entitled "LAGOVIRUS AND LAGOMORPHS, AN EVOLVING RELATIONSHIP" which aim was to describe the main steps in the evolution, identification, diagnosis and characterisation of the different pathogenic and non-pathogenic lagoviruses of rabbits and hares, as well as to indicate their main epidemiological features and control strategies. Three partners of the Lagmed were among the presenters of the seven talks included in the program.

Among the various training activities, the partners of LAGMED ensured the supervision of internships (BSc master and PhD) but they also get benefit, as visiting scientists, from short term missions. Indeed, since a main objective of LAGMED is to strengthen scientists and technicians training on diagnosis, molecular epidemiology and biosecurity measures of Rabbit Hemorrhagic Disease, we "opened the door" of IZSLER to foreign scientists for visiting the laboratories in order to receive training in the target areas of this project.

A Tunisian colleague attended in March 2022 the WOAH Reference Laboratory for RHD at IZSLER for a period of one week to update and discuss on the methods used for the virologic and serologic diagnosis of RHD. Few weeks later, in June 2022, three Algerian colleagues had the opportunity to visit the IZSLER laboratories for one week. During the visit they learned the different methods of diagnosis of RHD, the production of monoclonal antibodies and autovaccines. Also, the last day of the course was dedicated to biosecurity measures: following a survey carried out in Algeria concerning biosecurity methods on rabbit farms, a working session was held with the aim of exchanging knowledge and providing orientation and proposing possible solutions that should be established in Algerian farms.

FINAL REMARKS

Although the development of this project has been strongly conditioned in its progress by the restrictions related to the COVID-19 pandemic, there is optimism among the partners in believing that the proposed and set objectives can be achieved. After all, the partners of the consortium not only have a long experience of project management but also the research staff of each institution involved in the proposal has a strong track record of scientific achievements including the management of large national, EU, and industry sponsored projects. Indeed, most of them are working in strict collaboration since many years and have participated together to a previous European ANIHWA Project entitled "*Emergence of highly pathogenic caliciviruses in leporidae through species jumps involving reservoir host introduction – ECALEP*". All this considering we sought and established collaborations to form a multidisciplinary team which makes us confident that all the tasks will be successfully completed in due time, and along the lines established in the work packages. In fact, the teams involved can fill-in gaps in the know-how and networking capacities presently available and each partner's expertise will be a valuable contribution for the consortium.

By completing this project, we expect to shed light on the epidemiological dynamics and modelling of this animal disease that concerns a species considered "minor" as zootechnical productions, but that for its severity and ease of diffusion has few equals in the panorama of infectious diseases that concerns both animals and man.
Indeed, our hope is that the outcomes of the project could also have an impact on government decisions of the countries involved in the partnership and although this is not a technological product per se, the results will be used in a real setting of application by the government agencies responsible for the biosecurity measures in the target countries. We also expect to develop a new concept of RHD diagnosis, by developing more accurate, sensitive and rapid diagnostic tools. Notably, this is expected to prevent new outbreaks and mitigate disease impact and mortality. A strategic part of this proposal is the development of more efficient vaccines. This new product might allow the implementation of new services in already existing companies, increasing economic growth.
Finally, it should be remarked the spirit of cooperation that animates the project since it has offered us the opportunity to meet new colleagues from Mediterranean countries and to provide them training opportunities with the aim to form scientists and technical staff with a solid background in different fields of RHD research as epidemiology, animal experimentation, virological and serological diagnosis, vaccine assessment or biosecurity and intervention plans.

SUGGESTED FURTHER READINGS

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MANAGEMENT AND ADMINISTRATION OF THE PROJECTS WITH THE AIM TO DEVELOP RABBIT FARMING IN DEVELOPING COUNTRIES

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The National Association of Italian rabbit breeders "ANCI" represents the point of Italian rabbit farming and has as a main objective the genetic improvement of Italian meat rabbit breeds, such as Bianca Italiana, Macchiata Italiana, Argentata italiana – together with the preservation of Italian rabbit biodiversity including 43 breeds in addition to 3 principal main ones. According to the 3rd article of the Statute, our association has a technical and economic character and propose to promote and actualize the initiatives for contributing to genetic improvement of rabbit breeds and to the increase and valorization of rabbit species and of the derived products.
The first institutional activity is represented by the keeping of the Genealogical Book, which refers to three Italian rabbit breeds, e.g. Bianca, Macchiata and Argentata Italiana, which are subject to specific genetic selection according to litter weight, teats number and individual weight (Bovo et al., 2021). The Genealogical Book represents the instrument for the genetic improvement of rabbit breeds with special regard to the genetic evaluation and certification of single breeders. The activities of livestock enrolled in the Genealogical Book are directly executed by Genetic Center ANCI in Volturara Appula (FG). The Rabbit Genetic center handles selection activity of single breeds and their economic valorization in order to improve their productive and reproductive performances. Technical activity of the Genealogical Book, sector of genetic improvement, is based on direct management by ANCI of the Central Nucleus livestock and the activities of enrolled breeders. The selection strategy is based on a novel organizational model that Central Nucleus livestock is the origin of the selection activity trusting in enrolled breeders to crossbred pure breeds to rise etherosis effect. The crossbreeding process involves a three-steps path through Bianca Italiana doe is hybridized with Macchiata Italiana buck giving rise to F1 lineage; finally, the F1 doe will be crossed with Argentata Italiana buck, producing F2 generation of meat rabbits.
The second institutional activity is represented by Rabbit Registry, as an instrument for the safeguard of endangered Italian rabbit breeds with special regard to the conservation of their morphological standard and their genetic variability. The Rabbit Registry includes 43 rabbit breeds acknowledged by the Ministry of Agriculture, Food and Forestry. These breeds are widespread in the Italian territory and involve 500 rabbit breeders, who are home breeders, and 10.000 animals. Rabbit breeds enclosed in the Rabbit Registry are selected according to specific morphological and

functional standards (Ballan et al., 2022). Connected to the Rabbit Registry, ANCI has also the detection of the Register of Experts. More broadly, ANCI supports the development of national rabbit farming and offers its technical assistance to rabbit breeders through: business development plans; reproduction programs by artificial insemination; supply of qualified rabbit breeders; technical appraisal reports; information and dissemination; price monitoring in addition to marketing survey; information about rules of interest for farmers; study and research activity in collaboration with scientific entities.

Another central activity carried out by ANCI, is keeping its relationship with public entities at each level for representing interests of associated people. ANCI does also promotional activities for increasing the consumption of rabbit meat and by participating to European, national and regional rabbit fairs. Moreover, it supports and serves in ten rabbit fairs throughout the country. Now ANCI is devoted to the realization of project within the frame of the National rural development plan for the safeguard of the biodiversity of Italian rabbit breeds and for several years focused on the creation of promotional projects for Italian rabbit farming all over the World.

From 1999 to 2002 ANCI gave an important contribution to the realization of the Permanent International Observatory for the development of rabbit farming in the countries of the Mediterranean Basin together with other important international organizations such as ASIC, CIHEAM, FAO, WRSA, etc.

In 2010 ANCI began the first delivery of rabbit breeders towards the World e.g. China, Korea, Bulgary, Albany and Greece.

In 2012 together with the Ministry of Agriculture, Food and Forestry and other members, ANCI was involved as partner for "*Ciquaas*" project for the valorization of Italian rabbit.

In 2015 ANCI launched a project for promoting Italian rabbit farming in Eritrea where it was possible to establish a bilateral cooperation between Italian and Eritrean experts in rabbit farming. The challenge was undertaken by the director of ANCI, Michele Schiavitto, who decided to visit the place to start the design of a little genetic center for rabbit breeding in the capital city Asmara. The project arose in 2012

Figure 1. A group of Eritrean experts during the training period with Professor Schiavitto (a); Little "Rabbit Genetic Center" in Eritrea (b).

after the Agriculture Ministry of Eritrea Arefaine Berhe visited the Genetic center of Volturara Appula. He was so excited owing to the great potential of that center that he decided to build a similar one in Eritrea. After about two years, the project began and some Eritrean technicians were hosted in Italy at the genetic center in Volturara Appula to start a training period for studying management procedures of rabbit farming (Figure 1).

Then, after building of the genetic center in Eritrea, ANCI delivered the first group of selected rabbit breeders (250 animals) which developed a great adaptative capacity to climate change although they were fed only by herbs and grains because of lack of specific feeds. The Rabbit genetic center of Eritrea obtained many successes and for a short time, it was supported by ANCI until the achievement of self-sufficiency.

In 2019, ANCI began the realization of an international project in Uzbekistan to create rabbit genetic center at Tashkent that is actually still in extension. The project started after an exchange with a group of Uzbek agricultural entrepreneurs who visited the genetic center in Volturara Appula and includes 27 sheds that will be populated by selected rabbit breeders of Bianca Italiana and Macchiata Italiana breeds. The design of the 27 sheds has been realized by unit of specialized engineering that moved to Uzbekistan to analyze specific parameters of the territory and all necessary material for laboratory and other equipment have been delivered from Italy. Each shed was sub-divided into two sections (Figure 2), one for rabbit farming and one for empty sterile cages for all-in/all-out system and to ensure the optimization of health management reducing disease transmission. Three sheds are currently available and respect cyclized mating plan for rabbits. As occurs at the Genetic Center of ANCI, the data collection about productive and reproductive performances is executed using specific software that has been properly designed by a group of informative experts (Figure 3).

Since May 2022, ANCI is highly committed to foreign front in developing countries especially in some regions of Sub-Saharan Africa for promoting products of ANCI Genetic center.

Figure 2. Design of Uzbek rabbit genetic center in Tashkent.

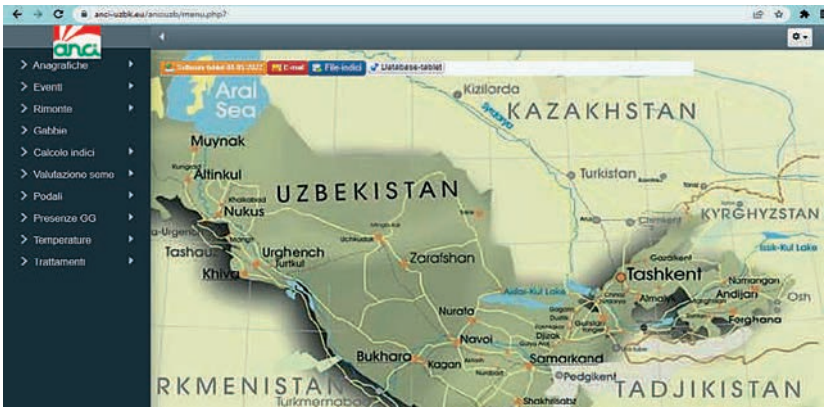


FIGURE 3. Screenshot of database home for on-line processing of data collected in Uzbek rabbit genetic center.

For several decades, Africa was threatened by a high level of poverty becoming more worrying over the years. According to the World Bank report, between 1993 and 2002 people living below the poverty line (1 dollar a day) in Sub-Saharan Africa increased from 200 to 220 million in rural areas and from 80 to 100 million in urban areas. According to some experts, the number of rural poor has continued to rise and will likely exceed the number of urban poor by 2040 (World Bank, 2008). Across the continent, country profiles have revealed that over a 12-years period, poverty in Sub-Saharan Africa ranged between 28% and 80% of the entire population with differences between regions (e.g. North vs Sub-Saharian Africa) or by location within countries (e.g. rural vs. urban areas). In rural areas, native people live from products of agriculture and from farming of little species including rabbits that have been promoted as a tool for poverty alleviation (Oseni and Lukefahr, 2014). For over three decades now, the contribution of smallholder rabbit units in developing countries has been clearly recognized because it favored the increase of food security associated to the possibility to access secure food amount, which is sufficient for population needs. Over the time, rabbits were considered as low cost and rapid benefit species owing to their rapid development and the possibility to use removable resources for feeding them. Moreover, you can get in full the most out of this species as by producing meat for native people subsistence, as by deriving leather and fur for clothes, as by using bones for feeding other species and collecting their urines for land fertilization. Many reports mentioned the advantages of projects about the development of rabbit farming in Africa such as: reducing poverty level, increase of rural areas, arise of entrepreneurial capacity of native people, humanitarian services and low migration level. The first projects started in 70's through the support provided by global organizations and foundations for rabbit research and development as "FAO" Food and Agriculture Organization of the United Nations for rabbit projects. Also, it is noteworthy the contribute by the International Foundation for Science (IFS, Stockholm, Sweden) for young scientists in the developing world for research and development programs that supports efforts towards poverty alleviation, such as the international workshop on

rabbit farming in Africa in 1978 that represented an event of great relevance as Tanzania, Sudan, Mozambique, Togo, Ghana, Zambia evidenced importance of rabbit farming (Martiniello, 2016). That event terminated with the publication of the first scientific papers stressing the relevance of management of rabbit farms in Africa by smallholders, improvement of reproductive performances and health management. In the 90's, rabbit farming played an important role in the reduction of juvenile migration level from rural to urban areas in some developing countries, e.g. Nigeria, Egypt, Ghana, Morocco, Capo Verde favoring low poverty level of native populations. Since then, many projects concerning the development of rabbit farming were established in African continent involving different partnerships such as:

– the CECURI project of Benin Republic (Lebas et al., 1997; Kpodecon and Coudert, 1993) set up to vitalize the rabbit production sector where the promoters emphasized the need for local solutions to feeding, genetics and housing challenges;
– the Heifer Project International - Cameroon Rabbit Project (or HPI-CAM) that had the goal of improving family nutrition and income and also enhancing community development and gender status in villages in Cameroon (Lukefahr et al., 2000);
– the National Rabbit Project of Egypt which involved collaboration between Zagazing University in conjunction with Egyptian Academy of Scientific Research and Technology. The breeding objective involved the distribution of purebred Californian and New Zealand White rabbits, which are mainly used for slaughtering (Galal and Khalil, 1994);
– the Egyptian farmers project coordinated by the United States Agency for International Development (USAID) and the National Development Agricultural Bank of Egypt was established to promote rabbit production in rural areas through soaft loans;
– the Rabbit Research Project at Bunda College of Agriculture,Malawi focused on nutrition, animal care, housing and general management (Mc Nitt, 1979);
– FAO and CIHEAM support for rabbit project development for promoting rabbit breeding in Tunisia which favored development of new technologies and continues government support including international organizations such as FAO and with initiatives such as the International Observatory on Rabbit Breeding in Mediterranean countries (Belli et al., 2008);
– National program of rabbit production in Mozambique (Gaspari, 1979; Demeterova et al., 1991). The project was implemented to provide housing, breeding stock and training facilities for people with a strong emphasis on renewable resources (especially forages) for feeding rabbits.

Although the implementation of these projects allowed to increase the productivity of rabbit smallholders encouraging poverty reduction, over the years, numerous difficulties were encountered because of climate change affecting rural areas in addition to political conflicts and disorders, highly increasing dislocated refugees. According to the latest official estimates, between 2012 and 2016, poverty increased moderately from 19.7% to 21.4%, and inequality rose as the Gini index went from 41.0 to 42.8. This was the result of the overall economics lowdown observed during that period, coupled with a severe drought that affected the country in 2016 and 2017. Multi-dimensional poverty incidence, which in addition to the monetary dimension includes

measures of human capital deprivation and access to basic services, reached almost 60% in 2016.The factor that contributed the most was low access to basic services, mainly improved sanitation and electricity. Important geographical disparities remained: rural areas lag behind urban centers along most dimensions, and the Eastern and Northern regions comprise 3/4 of the monetary poor. The effects of COVID-19 outbreak also will likely result in an increase of monetary poverty and stall progress in some of the human capital indicators, due to disruptions in the delivery of education and health services causing severe problems and arising the daily mortality level (UNICEF Uganda, 2014). The most vulnerable are newborn under 5 years old. Every 1,000 born alive, 28 die since acutely malnourished or affected by other diseases. Uganda remains one of the main places for refugees from South Sudan where civil conflicts permain. In January in 2018, the number increased to 1,411,794 refugees. Their presence in Uganda induced high level of competition for food resources in the territory with negative consequences of economic, social and environmental impact (World Bank and Kilimo Trust, 2020).

Against this background, no-profit project for combating poverty for building rabbit genetic center in Uganda was established in particular in Adjumani district. The project was initiated in July in 2022 and was designed by NGO ANAWIM AFRICA supported by ANCI under guidance of the director Michele Schiavitto in collaboration with Lucera Rotary Club and the company Meneghin Srl for the realization of a rabbit genetic center and for promoting Italian rabbit farming. The seat of Adjumani District has a latitude of 3°22'42.17"N and a longitude of 31°46'56.02"E at east bank of Albert Nile river which is in common with Moyo district. It borders south and est Amuru district, west Arua and Yumbe districts and north Moyo district. Adjumani is one of districts forming common boundary between Uganda and the Republic of southern Sudan-north-east part. The territory extends over 3,128 km^2 of 46.8 km^2 is underwater. Forest area is about 37.44 km^2. During the last years, Adjumani district hosted a lot of refugees from Southern Sudan and other areas of Uganda and consists of 18 villages for dislocated refugees about 58% of natives. Known as "*refugee settlements*", they are like little towns where Ugandan government provides for each family 900 m plot for building home and farming ensuring a food amount of 12 kg per month per person, free healthcare, and moving. Villages for refugees lack of fence, therefore adults are free to move and organize their life engaging business activities, while children attend local schools. In addition to acceptance politics, since 2018, Adjumani district has designed a plan for social-economic development and life sustainability of this area. This plan involves new strategies for managing rural farming through know how training and creating a market network among rural smallholders to promote products deriving from private ones in order to ensure the use of all identical resources favoring food security for everybody. In addition, non governmental organizations also cooperated with political bodies for social welfare. Within this framework, the realization of a rabbit genetic center rightly agrees plan for social-economic development and life sustainability in Adjumani district to reduce poverty level. Therefore, as previously for Eritrea, the project in Adjumani district has been implemented by the organization of a training period for local experts of rabbit farming together with Italian experts under the guidance of Dr. Schiavitto.

The first meeting was organized in 2022 in May in Uganda where feasibility analysis for evaluation of territory of Adjumani district and learning ability and business skills of people opened to novel strategies of rabbit farming management has been done (Figure 4). Then during July, the first cages, water through, other devices for the rabbit genetic center were delivered in Adjumani. In the third step, the delivery of live animals destined to natural mating, health control and other equipment for artificial insemination and analysis of reproductive performances towards Adjumani district will be carried out.

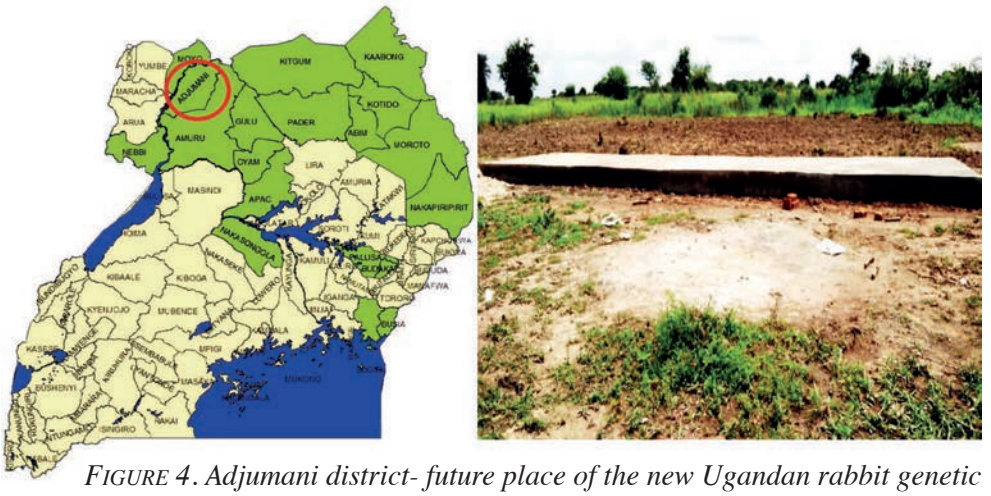


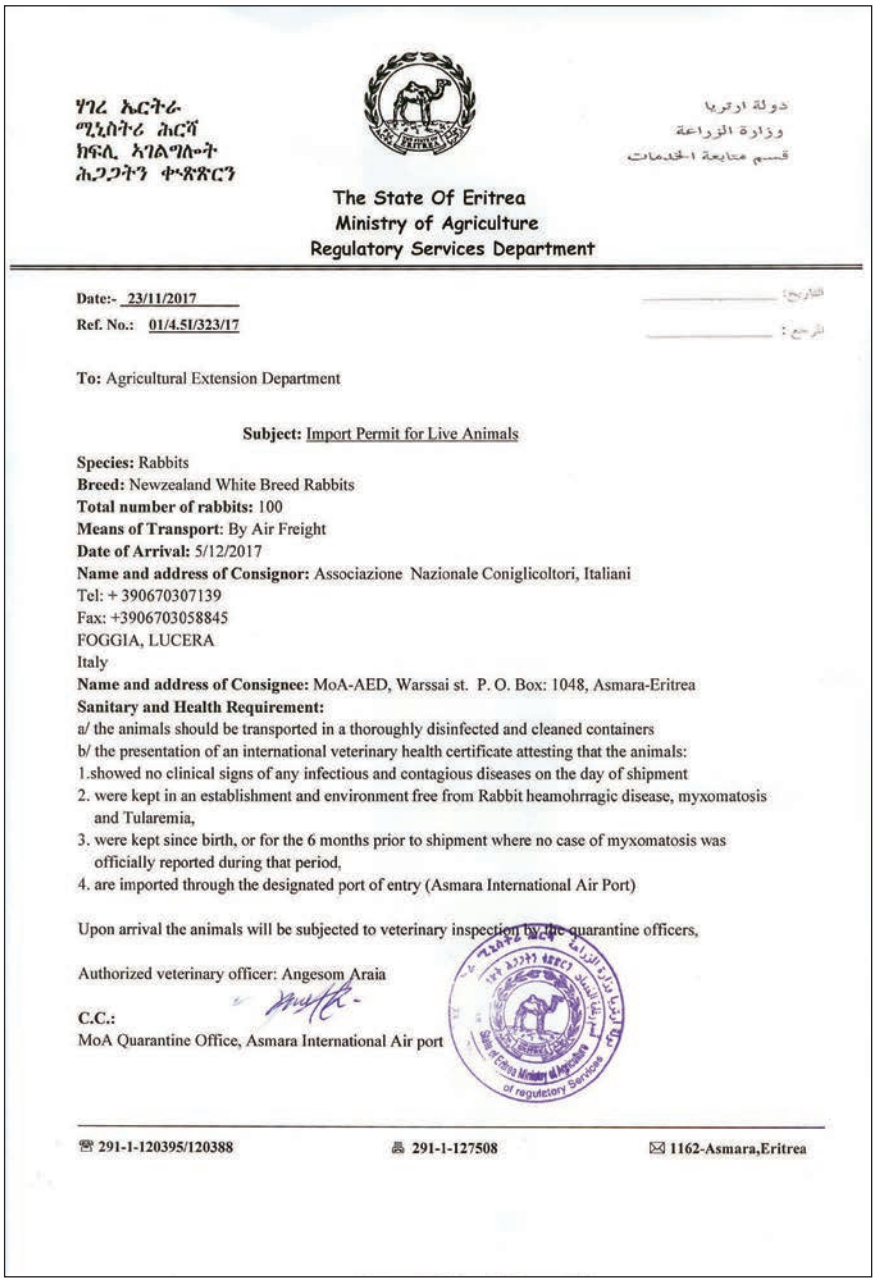
FIGURE 4. Adjumani district- future place of the new Ugandan rabbit genetic center.

The delivery time of live animals towards foreign countries represents one of the most crucial steps because it requires specific documentation. The right compilation of each document is fundamental for a successful delivery. First, specific permit for moving live animals (CITES permit), then TRACES system for data recording and documents for custom inspection are needed.

CITES PERMIT

Trading of live animals is strictly regulated by the Convention on International Trade in Endangered Species of Wild Fauna and Flora-CITES draft in 1975 at Washington and applied in Europe as CE 338/97 regulation integrated and modified as CE 865/2006 and UE 792/2021 regulations (concerning the right formulation of certificates and documents established by in force regulation). According to this Convention, trading of animals is ruled by rigorous regulamentation in order to prevent threatening their survivability and has to be authorized under special conditions. That Convention includes:

– each species, sub-species or geographically separate population;
– every animal or plant, alive or dead;



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دولة ارتريا
وزارة الزراعة
قسم متابعة الخدمات

The State Of Eritrea
Ministry of Agriculture
Regulatory Services Department

Date:- 23/11/2017
Ref. No.: 01/4.51/323/17

التاريخ: _____
المرجع: _____

To: Agricultural Extension Department

Subject: Import Permit for Live Animals

Species: Rabbits
Breed: Newzealand White Breed Rabbits
Total number of rabbits: 100
Means of Transport: By Air Freight
Date of Arrival: 5/12/2017
Name and address of Consignor: Associazione Nazionale Coniglicoltori, Italiani
Tel: + 390670307139
Fax: +3906703058845
FOGGIA, LUCERA
Italy
Name and address of Consignee: MoA-AED, Warssai st. P. O. Box: 1048, Asmara-Eritrea
Sanitary and Health Requirement:
a/ the animals should be transported in a thoroughly disinfected and cleaned containers
b/ the presentation of an international veterinary health certificate attesting that the animals:
1.showed no clinical signs of any infectious and contagious diseases on the day of shipment
2. were kept in an establishment and environment free from Rabbit heamohrragic disease, myxomatosis and Tularemia,
3. were kept since birth, or for the 6 months prior to shipment where no case of myxomatosis was officially reported during that period,
4. are imported through the designated port of entry (Asmara International Air Port)

Upon arrival the animals will be subjected to veterinary inspection by the quarantine officers,

Authorized veterinary officer: Angesom Araia

C.C.:
MoA Quarantine Office, Asmara International Air port

State of Eritrea Ministry of Agriculture of regulatory Services

☎ 291-1-120395/120388 | 291-1-127508 | ✉ 1162-Asmara,Eritrea

FIGURE 5. Example of import permit.

– all endangered species at risk of extinction which are or could be destined to trading exchanges;
– every species which not necessarily are at the moment but could be at future risk of extinction when the trading of those specimen species won't be regulated by strict regulamentation aiming to prevent their exploitation which is not compatible with their survivability;
– other species that has to be under regulation in order to make effective the control of specific traded species specimens;
– all species that are partially regulated within its jurisdiction only to limit their exploitation and to request the cooperation of other juridical components for trading control;
– such Convention establishes that any import, export and re-export of products derived from protected species under current convention will be subordinated to the presentation of specific license (mandatory permit) or certificate declaring specimen species are protected by CITES convention.

License and certificate have specific requirements:
– to be granted under the provisions of Articles III, IV e V of Convention and shall comply the provisions of Article IV of the Convention;
– to include information reported in detail in the template form of Appendix IV to be valid for export for 6 months from the date of issue;
– to report the title of the Convention, name and stamp and the control number issued and assigned by the management authority;
– replicates of certificates or licenses issued by management authority have to be marked as "*copies*" and cannot be used as original documents without specifying on it;
– for each species specimen separate accompanying license or certificate is required;
– import management authority specific for species specimen will declare null or will keep export license or re-export certification and eventually import permit related to import of specific species specimen (Figure 5). If this will be possible and legal, a management authority will label species specimen allowing its identification. For this reason, as "*label*" every permanent mark, brand or lead seal to identify species specimen for preventing unauthorized falsification is intended.

Finally, the scientific authority of export country has to declare that:
– export won't be harmful for the survivability of the species of interest;
– species specimen was not obtained in contravention of the laws of that State for the protection of fauna and flora;
– each live specimen was packed and transported for minimizing risk of lesions, disease or abuses.

TRACES SYSTEM

According to the decision 2003/623/CE, handling of live animals or animal products from European Union or third countries has to be monitored through unique traceability system known as "TRACES" (TRAde Control and Export System). Under EU 2017/625 regulation about official controls for agri-food chain, TRACES system has

been enclosed in European Union system for treatment of information control "IMSOC" Information management system for official control involving other three informatics systems such as "RASFF" *Rapid Alert System for Food*, "ADIS" *Animal disease information system*, "EUROPHYT" *European Union Notification System for Plant Health Interceptions*.
TRACES system was designed as an informatics veterinary platform to report, certificate and control import, export and trading of animal and animal products This system is applicable to:

- live animals (harmonized and not harmonized species);
- genetic material (sperm, oocytes ed hembrions of cattle, swine, ovine, caprine, horse and other animal species);
- animal products not for human consumption (products under EC 1774/2002 regulation).

The new informatics system TRACES ensures the management and registering of all import data subject to veterinary check and computerization of import certificates issued by Places of Frontier Inspection "PFI", known as Common veterinary entry document (CVED) as established by the Decision 2003/279/EC of 15 April 2003 for products (CVED P) and the 2004/282/EC regulation 18 February 2004 for live animals (CVED A).
Moreover, it allows each Member State to have data of imports through PFI and EU, providing a wide vision of data about the totality of live animals or animal products that are imported by third countries. The main characteristics of the TRACES system are:

- electronic transmission of information;
- centralized management of reference regulatory;
- interoperability with other informative systems;
- multilanguage.

It allows to:

- improve quantity and quality of information about live animals moving;
- increase exchange of information between national authorities and the European Union;
- create electronic veterinary certification system allowing companies to recover information on-line;
- manage the list of establishments of extra-European countries authorized to export animal products in EU;
- manage rejected shipments at EU borders;
- centralize controls on public and animal health and welfare (above all during the transport, etc.);
- centralize the evaluation of potential risk of epidemic outbreak;
- overcome language difficulties making more accessible the information from other countries;
- insert all the involved operators creating a system of development for the documents exchanges between companies and competent authorities.

Producers and Companies can be enclosed in the TRACES system if registered at the competent authorities. To transport animals or animal products, standard electronic form should be filled out including all information about animals or animal products, destination and every stage of the itinerary. For animals or animal products trading in European Union, informations are transmitted by the competent authority of the country of origin in European Union. After check, competent authority can approve or reject delivery.
When appropriate, health certificate and plan of itinerary with specification about healthy conditions of animals presented in the official languages of both countries of origin and destination are issued. Private operator cannot perform the transport without authorization. In case of import or export of live animals or animal products towards or from extra-European countries, custom agents at the Border Inspection Post when controlling animals or animal products and checking veterinary entry documents should enclose these informations into TRACES database. They should issue a Common Veterinary Entry Document "CVED" including import permit or rejection of entry into the European Union. All informations have to be send to the authority of EU country of destination, central veterinary authority of a place or places of transit and all inspection posts. All information can look up in case of checks performed during the itinerary or at the arrival at the place of destination. This information can be accessed also by companies registered in database. Informative system is freely available for every user.

COMMON VETERINARY ENTRY DOCUMENTS "CVED"

The Common Veterinary Entry Document (CVED) authorize import of live animals or animal products from third countries in the European Union. In case of live animals, suitability is declared by the country of origin by means of health certificates issued by the veterinary authority of the origin country and presented as attachment. For rabbits in particular, health certificates should enclose vaccination for Rabbit hemorrhagic disease (RHD) and myxomatosis. The CVED documents have to be enclosed in the TRACES system and consist of two sections one for the country of origin and another one for place of destination (Figure 6). The first section should be filled out by the authority of origin country to pre-notify import or trade of live animals or animal products in the European Union 24 hours before delivery. The second section should be completed by the Veterinary Administration Services certifying that delivery has been checked at the Border inspection post (BIP) and declare that, following control, shipped material can be transported into the place of destination.
Compilation of CVED documents is necessary for transport of live animals (cattle, ovine, caprine, swine, horses), animal products (such as eggs, hunting trophies, furs, sera, etc.), animal products not for human consumption, but is not required for non-commercial movements of pets.

OTHER DOCUMENTS

Generally, to complete documentation for the delivery of live animals towards European and Extra-European countries, other documents have to be prepared:

– **sales invoices** without tax, including address data, net and gross weight, number of animals with specifications on breed and sex of animals;
– **responsibility certification** of producer company (*Shipper responsibility*) with detail about number of animals and boxes for delivery and possible presence of other equipment, such as urine collector systems, drinkers to minimize stress conditions for animals during transport;
– **transport certification** of live animals by producer company to declare that delivery content has been properly packaged and labelled according to IATA guidelines (IATA, 2021) and animals are health under the Convention on International Trade in Endangered Species of Wild Fauna and Flora-CITES (*Shipper certification for live animals*);
– **certification of manufacturer compliance** of delivery boxes used for transport of live animals;

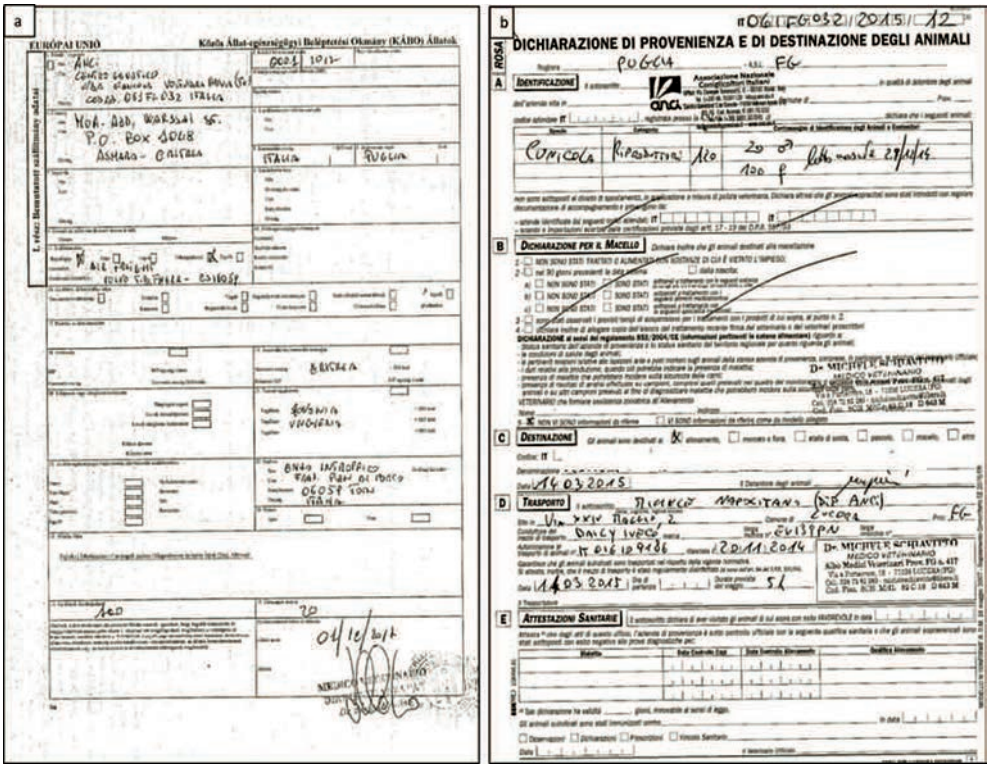

Figure 6. Example of the Common Veterinary Entry Document (CVED) (a); Form 4 (b).

– **form 4** corresponds to the accompanying origin declaration for transport of live animals and has to be issued by producing for replicates, one for delivery company, one for the veterinary service of Local health authority of the place of departure, and finally one for the health authority service of the place of arrive. These forms have three different colours depending on the place of origin, pink from a farm, green from a lairage facility, yellow from a fairy or marketplace. Despite importance of this form, its digitalization is still sporadic above all in case of delivery from Italy towards extra-European countries. In fact even if it has used only in Italy, it is important because animals are usually delivered by land transport towards airport station and then by air freight towards the place of destination;
– **international waybill CMR (***figure 8a***)** is a document to certify the acceptance of the order for road freight transport when the place of supply and that one of delivery are located in different Countries. This is a real transport contract produced by shipper (or freight forwarder) that is countersigned by courier as proof of agreement between both parties involved in delivery path, modalities and conditions of transport to be conform to CMR International Convention (*Convention relative au contract de trasport interntional de marchandises par route*);
– **customs declaration (***figure 8b***)** which certifies that the shipments are not categorized as military equipment of the European Union and are not used to provide technical assistance for military activities.

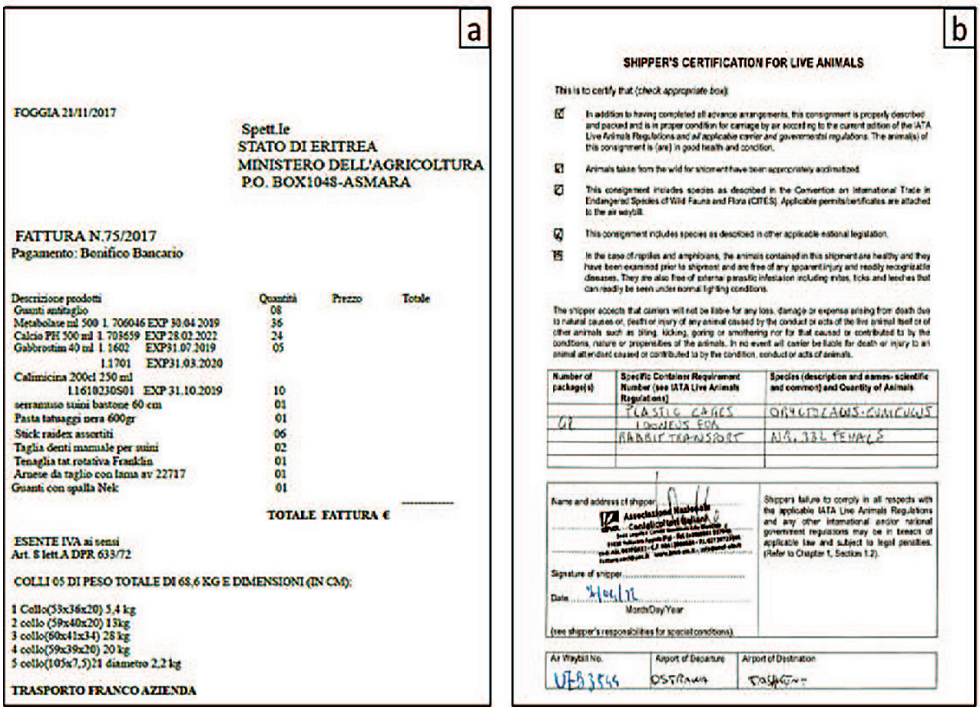

Figure 7. Example of sale invoice without tax (a); Shipper Certification for live animals (b).

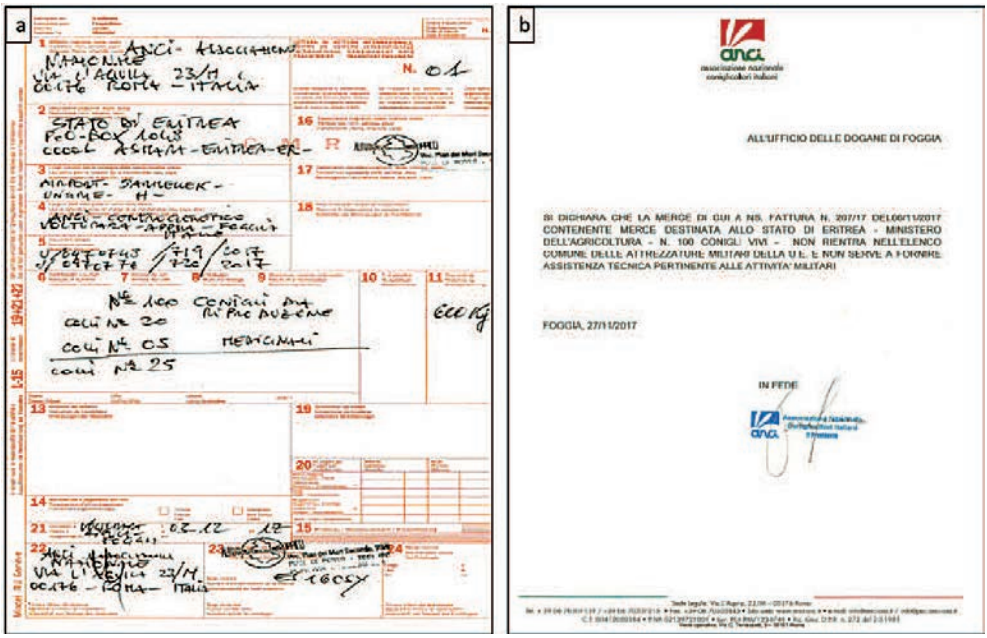

FIGURE 8. International waybill CMR (a); Customs declaration (b).

CONCLUSIONS

Although in all European or Extra-European countries digitalization of all form templates for moving and transport of live animals is still required, many countries especially developing ones do not conform to this system. Therefore, as the process associated to informative recording of data is still proceeding very slowly, despite of existing mandatory standard procedures, forms in hard copies are still used. The digital transition for all documents related to the transport of live animals will be essential for the total implementation of a data management network during transport to foreign countries and will ensure a greater security and stability of trades.

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