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Initiative pour la Diversité des Animaux Domestiques

Iniciativa para la Diversidad de los Animales Domésticos

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Review of global rabbit genetic resources: special emphasis on breeding programs and practices in the lesser developed countries

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Summary

Presently, there is little organization or co-operation among countries with rabbit breeding programs with the common aim of maintaining genetic diversity, with the exception of Europe and the Mediterranean region. Particularly in the lesser developed countries (LDC's), there is limited evidence that maintaining genetic diversity in rabbit populations is even a national priority. Based on consultancies and project experiences in over fifteen LDC's, and limited reports from the literature, evaluations of breeding programs at national rabbit breeding centers have generally been less than encouraging with regard to the management of genetic resources: utilization and conservation. The purpose of this position paper is to review rabbit genetic resources management practices and trends in rabbit breeding program development which pertain to genetic resources utilization and conservation issues, and with special emphasis on the LDC's. Several measures are discussed that could enhance breeding program integrity, greater benefit limited-resource farmers, and also foster international and regional participation in rabbit genetic resources conservation programs.

Resumen

Actualmente, salvo en Europa y en la región mediterránea, existe sólo una pequeña cooperación entre países en cuestión de programas sobre razas de conejos con el objetivo común de mantener la biodiversidad genética. En particular, en los países menos desarrollados (PMD) el mantenimiento de la diversidad genética de las poblaciones de conejos no forma parte de las prioridades nacionales. Basándonos en consulencias y proyectos realizados en más de quince PMD, así como en algunos informes presentes en la literatura, podemos decir que las evaluaciones de los programas de mejora de razas de conejos en los centros nacionales han sido, en general, poco alentadoras en lo referente a la gestión de los recursos genéticos: utilización y conservación. El objetivo de este artículo es revisar las prácticas de gestión de los recursos genéticos en conejos y las tendencias en los programas de desarrollo de mejora relacionados con la utilización de los recursos genéticos y posibilidades de conservación, todo ello con especial referencia a los PMD. Se discuten varias medidas que podrían aumentar la integridad de los programas de mejora, beneficiar ampliamente los recursos limitados de los agricultores y también favorecer la participación internacional y regional en los programas de conservación de recursos genéticos de conejos.

Key words: *Rabbits, Characterization, Utilization, Conservation, Genetic improvement*

Introduction

The first published report on the global need for rabbit genetic conservation programs and the organization of rabbit data banks was by Lukefahr (1988a). It is no coincidence that such program efforts, to date, have been most

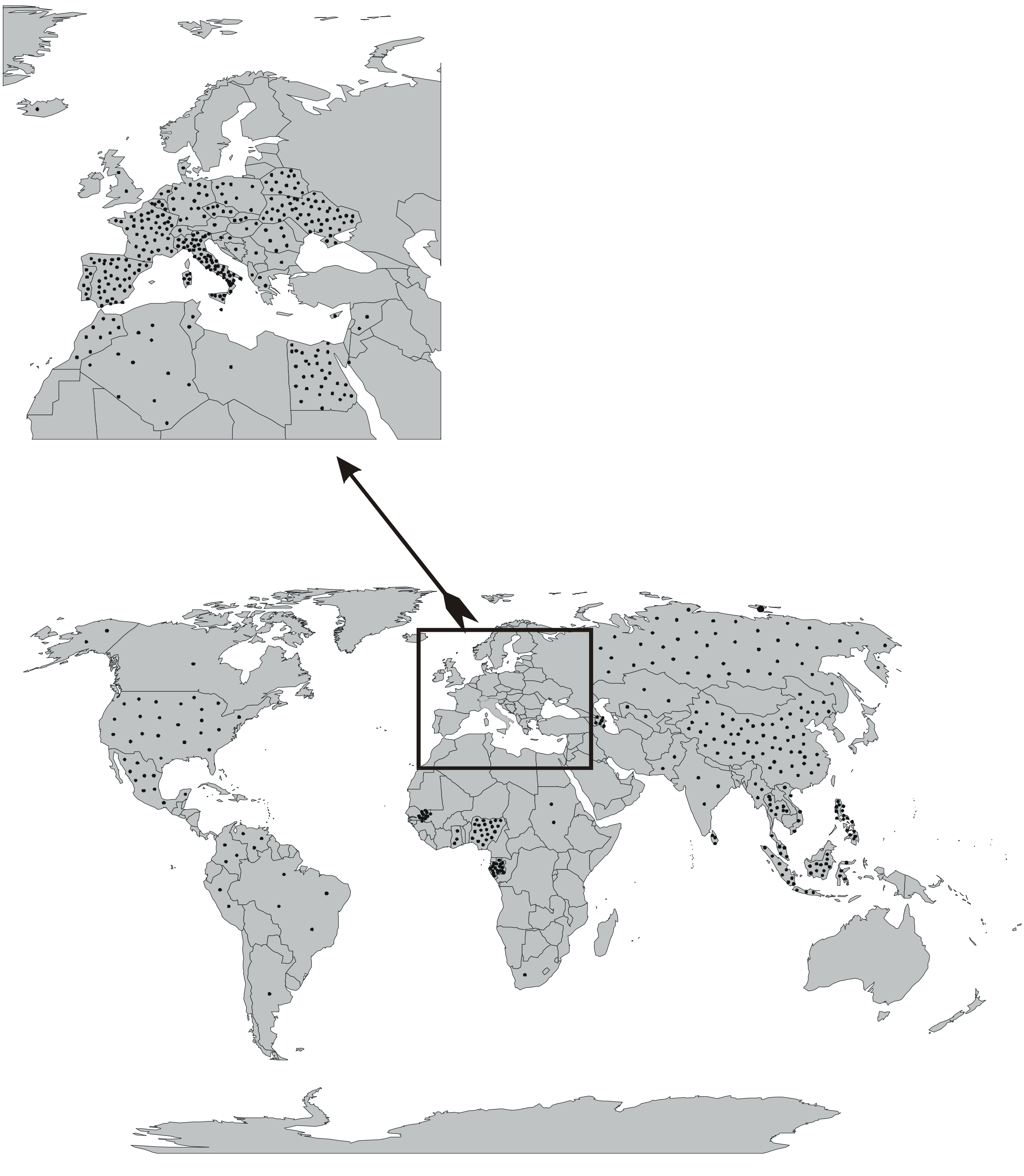

Figure 1. Female rabbit population in the World.
1 dot = 100 000 heads

active in Europe and in the Mediterranean region (Bolet *et al.,* 1996; Khalil, 1997) where the rabbit (*Oryctolagus cuniculus*) evolved and was first domesticated as a food source. According to Colin and Lebas (1995), 52% of the world's total number of breeding rabbit females (does) exist in Europe. Estimates of the world's rabbit population is 64 million does (Colin and Lebas, 1996) and 709 million total rabbits (Lukefahr, 1985). The global distribution of rabbits, based on country estimates by Colin and Lebas (1996), are presented in figure 1.

In the lesser developed countries (LDC's), the potential is greatest for inexpensively produced rabbit meat to offset national meat shortages (Owen, 1981). In recent years, small-scale rabbit projects have been gaining more international attention as a feasible measure for poverty alleviation and increasing of self-reliance in food production, two important elements in the World Food Summit Plan of Action (FAO, 1996). However, the world's distribution and level of productivity of rabbits is generally lowest in the LDC's (Lukefahr and Cheeke, 1991a) (figure 1). For instance, less than 5% of the world's supply of breeding does is estimated to be in Central and South America, only 14% in Africa, and 22% in Eastern Europe (Colin and Lebas, 1996). The same report figured that one-quarter of all breeding does exist in Asia; however, two-thirds of all rabbits in China (36% of rabbits in Asia) are reported to be of Angora breeds which are raised mainly for wool (Colin, 1995). It is evident from these figures that rabbit breeding projects in the LDC's should be expanded but also closely supported through international efforts that enhance active partnership roles such as in animal genetic resources management programs. Such international or regional efforts might be helpful in ensuring the maintenance of the genetic diversity in the rabbit for the development of sustainable production systems.

The purpose of this paper is to address several rabbit genetic resources management issues and constraints and to review trends in rabbit breeding program development with special emphasis on the LDC's. Recommendations will be made on realistic measures that might promote better management of rabbit genetic resources and that would also foster active regional and international partnerships in that respect.

Identification of Indigenous Breeds

Arnold (1994) reported that the rabbit was first domesticated in Europe as recent as the 18th century. Other reports indicate that domestication may have occurred as early as the 5th or 6th centuries (Sandford, 1992). One exception is the report by Chen (1984) which claims that the rabbit was first domesticated in China during the Han dynasty (206 BC to 200 AD). However, it is unclear if this involved a unique indigenous species or an introduction of European wild rabbits.

Indigenous breeds may only be found in Europe and the Mediterranean region in proximity to the rabbit's center of origin, which according to Callou *et al.* (1996) is Spain and the south of France. In this geographical context, indigenous breeds may possess the most developed adaptative qualities due to evolutionary forces. In Tunisia, local rabbits have small body size, small litters, large ears, etc.; the population has conformed to cope under adverse environmental conditions, although there is much variability within this population (Finzi *et al.,* 1988). In Egypt, Ibrahim (1988) noted that Baladi (Arabic for "local") and Giza local breeds had less dense fur than Bouscat Giant White and Flemish Giant breeds from European, and Shafie *et al.* (1970) observed that the Baladi White had lower pulse and respiratory rates and lower body temperature than the Baladi Black strain. Also, Gad *et al.* (1995) reported that NZW showed greater seasonal fluctuations in blood parameters and body weight gains than did Baladi rabbits. In Russia, the Soviet Chinchilla breed has been selected for dense fur (Miroshnichenko, 1984). Alternatively, in a socio-economic context, indigenous breeds may exist world-wide, for example, the

Criollio and Creole in Latin America and the Caribbean, the Japanese Large-eared rabbits in Asia, and "local strains" in Africa, India, Indonesia, etc.

Rabbits were probably first introduced to most LDC's less than 100 to 150 years ago. The most popular meat breeds: the Californian (CAL) and the New Zealand White (NZW), both of U.S. origin, were developed in the present century. The introduction of these two meat breeds, in particular, resulted in the displacement of indigenous or local breeds (Fauve de Bourgogne in France (Lebas *et al.*, 1997), the Carmagnola Grey in Italy (Pagano Toscano *et al.*, 1992), and the Spanish Giant in Spain (Martin-Burriel *et al.*, 1996) in many countries with a strong tradition of rabbit meat production. Later, this same trend occurred in Czechoslovakia, Hungary, Poland, and in other Eastern European countries. Such introductions continue to pose a threat to the existence of local breeds or strains.

One could divide indigenous breeds into standard and non-standard groups. Loosely defined here, a standard breed is continually selected according to a common breed description and/or performance criteria developed by a breeder's association. Generally, standard breeds are predominantly found in large commercial and/or fancy herds (*e.g.*, CAL, Dutch, Fauve de Bourgogne, NZW, and Rex), whereas non-standard breeds (*e.g.*, Baladi and Creole breeds) are more typically found in villages on small farms where they are reared under low-cost conditions (*e.g.*, fed fresh forages, seasonal breeding, and raised in hutches or underground). The rationale for this distinction is that selection criteria may well vary between these two groups. For example, a standard commercial breed may be selected largely for productivity (*e.g.*, large litters, rapid growth, and lean cutability). In contrast, a non-standard breed, may be selected largely for functionality (*e.g.*, steady reproduction [number of litters that a doe produces in a year], health history and/or rusticity). Such a major distinction should be accounted for in data bank descriptions. Of relevance, an observed trend in many countries is the displacement of indigenous breeds or local strains as a consequence of exotic or standard breed introduction. Local populations need to be characterized and inventoried so that conservation or even preservation programs can be considered before such valuable germ plasm is lost.

Aside from Europe and the Mediterranean region, considering the brevity since domestication, to what extent do breeds and/or "local strains" (generally undefined and indiscriminantly bred stock whose relatively recent but precise origin is unknown), as presently found throughout the world, represent unique genotypes for fitness and production characters? Has there been sufficient time for natural and artificial selection to produce real diversity between country populations (between and within breeds) so as to justify conservation programs in all countries or regions? Of relevance, Martin-Burriel *et al.* (1996) observed marked genetic distances between and within several French and Spanish rabbit breeds, but similar degrees of heterozygosity, based on electrophoretic variation for eighteen blood proteins (figure 2). In the next century, molecular genetic techniques (the reader is referred to the excellent papers by Zaragoza *et al.*, 1987 and Mulsant and Rochambeau, 1996) should be especially useful in solving some of these important issues to justify the extent of global rabbit conservation program activity.

Inclusion of Fancy Breeds

In the U.S., 45 rabbit breeds are recognized, but most are solely raised for show exhibition, and therefore might be questionable for inclusion in rabbit genetic resource programs. In the U.S., there is undoubtedly better organization among clubs engaged in fancy or show rabbit breeding than there is among groups of commercial rabbit breeders, perhaps due, in part, to marginal profitability in the meat rabbit industry. Hypothetically, under the prevailing socio-economic forces, it would probably be more challenging to conserve commercial breeds that provide food and fiber than it would be to conserve fancy

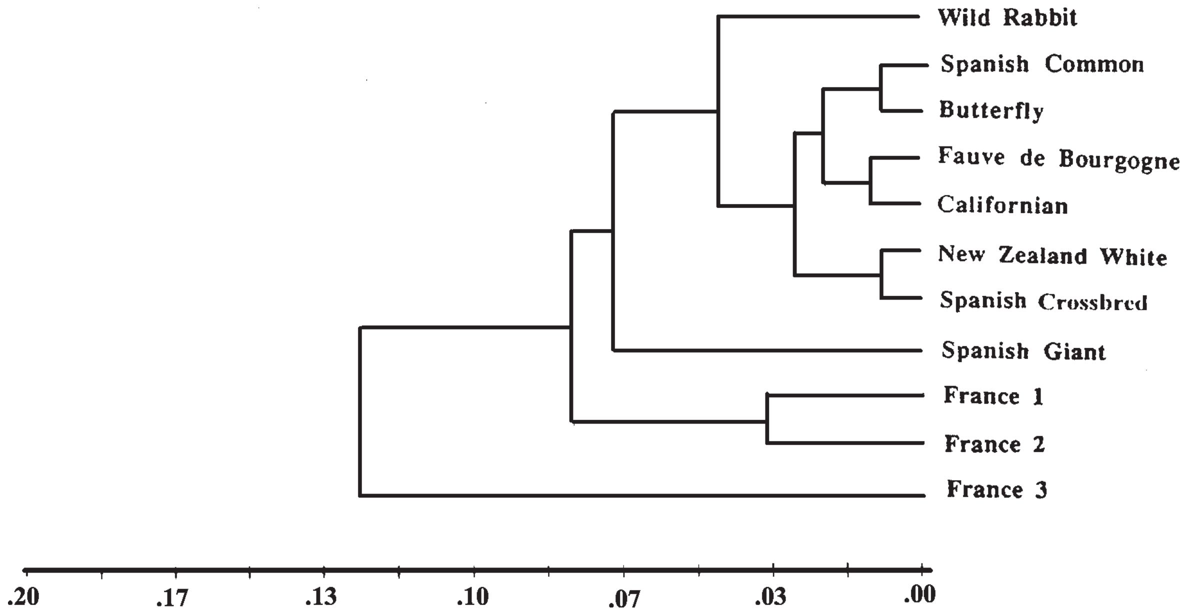

Figure 2. Genetic distance dendogram for rabbit populations [Adapted from Martin-Burriel et al. *(1996) and used with permission from F. Lebas, Editor, World Rabbit Science].*

Figure 3. Togo. Local rabbits displaying astounding phenotypic variability indicative of high heterozygosity levels in a small rabbitry near Lome.

breeds. The same dilemma may well exist in some other developed countries. Probably the only useful information available on U.S. fancy breeds is the annual number of rabbits by breed which are registered; however, such figures are probably well below the actual (albeit unknown) population size.

All breeds - commercial and fancy alike - should at least be included in initial characterization and documentation stages of data bank processing. Some fancy breeds should probably receive higher priority for possible conservation. For example, the Flemish Giant certainly possesses genes for rapid post-weaning gains, whereas the contribution of the Netherland Dwarf breed would be seemingly negligible.

The "Purebred" Stock Myth

There is generally good agreement that many rabbit breeds exported to other countries were later outcrossed to other breeds or strains. In developed countries, for example, a common practice among fancy rabbit breeders is to outcross to other breeds to incorporate more desirable genes for specific traits. This breeding practice raises the question; "Are all purebred breeds really purebred?" Obviously not. Moreover, the term "purebred" is a misnomer. The term, "straightbred", is more appropriate. Generally, straightbred animals breed true for only a limited number of simply inherited traits, such as for coat color and for major genes which affect fur type (*e.g.,* normal, rex, and angora) and body size (*e.g.,* dwarfism). If straightbreds breed true for all traits then there would be no genetic variation and hence no opportunity for genetic progress through selection. Therefore,

Figure 4. Tunisia. Impressive ear size of a local rabbit as a vital functional trait in thermo-regulation (Courtesy of A. Finzi).

attention should not be paid as to whether a breed is truly "purebred", but whether it is a distinct population that is utilized and worthy of conservation.

In the LDC's, where in many cases imported exotic breeds have been intercrossed with other breeds (including local strains), usage of the term "upgraded breeds" or "upgraded purebreds" is common. Should an upgraded NZW populations, for example, be inventoried as straightbred NZW? How should local strains, such as the Criollio or Kenyan White, be classified (*i.e.,* indigenous or non-native, straightbred or crossbred)? The critical decision is certainly not about which terms are most appropriate, rather it is about whether the distinct breed or strain is utilized, whereby it should be characterized, inventoried and conserved. Moreover, particularly in the LDC's, rabbit scientists should not adhere to the "purebred" myth under the popular notion, albeit false pretense, that purebreds are superior to local strains.

The Inbreeding Myth

In addition to claims of straightbred stock shortages in the LDC's, there also appears to be a common concern of deteriorative effects of inbreeding on production traits. In certain cases, especially where pedigree records have been maintained, the concern may be a genuine one because the integrity of a population could be at risk if inbreeding is not controlled. In other cases, the claim was unfounded and simply used to justify the request for a new shipment of exotic straightbreds. It has also been observed that such requests have many times involved small numbers of less than 30 breeding animals (usually because of high shipping costs or limited facilities) which would soon promote inbreeding. This pattern could yield a perpetual cycle of repeated requests for new stock. In the LDC's, a commonly observed practice among experienced farmers in rural villages is to exchange breeding bucks regularly to avoid close inbreeding.

Shortage of Straightbred Stocks

In the LDC's, a common problem claimed is the shortage of straightbred stocks. The real problem, however, is usually the lack of breeding infrastructure (*i.e.,* breed associations, breeding objectives, multiplication of improved stocks, and recording systems). However, upon close observation and inquiry at numerous national or regional breeding stations, it became evident that previously imported breeds were invariably later outcrossed to other exotic breeds or, if available, to the more plentiful local strain(s). Again, some station managers have referred to the outcross as an upgraded breed. Surprisingly, in a number of country visits, one practice is to take the offspring of outcrossed litters where there is segregation in simply-inherited genes for body coat color and group them accordingly, for example, into cage rows designated for CAL, NZW, Blue Vienna, and Chinchilla. Or, new breed names are assigned to the resultant outcross color variants (*e.g.,* "Country X" White).

Such practices would make the task seem insurmountable to ascertain real genetic diversity between breed populations among countries or regions. Molecular genetic analyses might possibly later reveal that such transitional genetic stocks are quite heterogeneous as opposed to genuine straightbred populations. If true, this could possibly be an advantageous situation because, especially in adverse environments, a high degree of heterozygosity or heterosis might be important for fitness-related characters (*e.g.,* fertility and survival) as a means of eventual local adaptation (Falconer and Mackay, 1996).

Role of Exotic Breeds

A major issue is the suitability of imported breeds ("exotics") typically from temperate regions for ultimate use by farmers in adverse tropical or arid regions. Personal observation suggests that exotics usually have fared quite

*Table 1. Exotic and crossbred mature stock inventory in 1975 at the National Rabbit Project in Ghana.**

	Surviving exotics		Born in Ghana			
			Exotic		Crossbred	
Exotic breed	bucks	does	bucks	does	bucks	does
Alaska	7	0	0	1	9	9
Blue Vienna	20	4	6	12	22	24
Californian	3	1	0	0	0	0
Champagne d'Argent	6	2	0	2	1	1
Chinchilla	3	1	0	0	0	0
Checkered Giant	2	1	0	0	0	0
Creme d'Argent	9	1	6	7	0	1
Flemish Giant	3	1	1	0	10	18
French Lop	2	1	0	0	2	1
Thuringer	15	4	1	11	3	3
Total	70	16	14	33	47	57

*A total of 120 animals were shipped between 1973 and 1974.
Source: Technoserve, 1975.

poorly under adverse environmental conditions at the farmer’s level on small farms (Lukefahr and Cheeke, 1991b). However, in less adverse environments, such as in the Sichuan province of China, satisfactory performance of CAL and NZW rabbits in peasant villages has been reported (Pu *et al.*, 1990). More research is needed to compare breeds under local farmer conditions.

In the LDC’s, there appears to be little incentive to develop new composite breeds that are better adapted under adverse environments. The author is familiar only with the reports from Brazil (Moura *et al.*, 1994) and China (Junlian and Fengyi, 1988; Zhen, 1992) on the development of new rabbit breeds which involved several generations of selection and some evidence that genetic progress was realized. It could be argued that in many LDC’s there is less interest in rabbit breeding and that there is also a general shortage of animal geneticists.

Further, what evidence exists that artificial selection within present breeds or local strains has been applied and shown to be effective in contributing to greater genetic diversity among populations throughout the LDC’s? An exception may pertain to Angora rabbit breeding where artificial insemination is practised in Chile (Kappel, 1985) and in China (Yan, 1988). Another notable exception is the history of rabbit breeding in Russia (Sandford, 1992). However, if diversity is detected, the precise cause (*e.g.*, effects of selection, outcrossing or inbreeding), as well as the original genetic profile of imported exotic breeds and/or local strains involved, may not be known.

Role of Locally Adapted and/or Heterogeneous Populations

The following example is characteristic of many such experiences involving poor adaptation of exotic breeds in adverse environments in the LDC’s but satisfactory performance of crossbreds in villages.

Figure 5. Dominican Republic. Appropriate use of adapted and hardy Criollo rabbits in a village development project managed by women.

Between 1972 and 1984, the National Rabbit Project (NRP) in Ghana received fifteen exotic breeds from Switzerland and the U.S. (Lukefahr *et al.*, 1992). Under local conditions of climate, fresh forage feeding with limited supplementation, and basic management, the exotics were eventually lost due to poor adaptation and/or low reproduction success (N. Mamattah, personal communication). Producing exotic x local (F_1) crosses as opposed to exotic straightbreds was generally more successful (table 1). The F_1 crosses were thrifty, had rapid growth rate, and had good fertility. In particular, when F_1 stock was later distributed to farmers for meat production in villages, breeding performance was satisfactory. Although crossbreeding was the solution in this case example, it is generally recommended that only breeds of merit (open to definition) be chosen for use in such a crossbreeding program.

In addition, a study conducted at the NRP (involving 687 rabbits and following several generations of *inter se* matings) reported a high heritability of 0.42 for 90-day body weight, which suggested the heterogeneous nature of this composite population (Lukefahr *et al.*, 1992). In agreement, Moura *et al.* (1997) estimated heritability of 0.48 for average daily gains between 56 to 84 days of age in 1 446 rabbits from a four-breed composite population in Hawaii.

It is the opinion of the author that the maintenance of heterogeneous and/or locally adapted populations may have real merit in some situations, despite the popular notion that such stocks are genetically inferior. In particular, locally adapted populations as opposed to exotic or upgraded straightbreeds may be more amenable for inclusion in genetic resources data banks and for effective conservation than attempts to reintroduce, identify or conserve exotic straightbreds or to develop new breeds at breeding stations. Local rabbits are prolific, tractable, and popular among limited-resource farmers. Another common observation is that local rabbits appear to be anatomically and

Table 2. Characteristics of anatomical and physiological soundness of local rabbits in tropical and arid regions.

Anatomical soundness

- Small to moderate mature size/large body surface area (possibly minimizes nutrition stress when the diet quality is poor/stress to high ambient temperature and/or relative humidity).
- Large ears in proportion to body size (effective means of coping with heat stress).
- Sound leg and feet structure (essential when reared on rustic hutch floors).
- Fur qualities (less dense, thin texture or diameter, and short fur to alleviate heat stress).
- Meat qualities (light to moderate rather than excessive muscling is less likely to lead to nutritional stress in fryers and in breeding stock).
- Number of functional teats (no less than 6 to 8).
- Well developed testicles and scrotum.
- Light versus dark body coat color may be advantageous.
- Absence of genetic defects (splayed legs, malocclusion, *etc.*).

Physiological soundness

- Adaptability to climate - Basal metabolic function (*e.g.,* normal pulse and respiratory rates and body temperature). Normal fertility (gametogenesis) even in hot weather.
- Adaptability to sub-optimal diets (high forage intake/appetite and good digestion efficiency).
- Adaptability to hutch confinement (resistance to stress associated with boredom and/or inactivity).
- Docile temperament or behavior.
- Resistance to disease and parasites (under proper basic feeding and sanitary conditions, local rabbits are noted for their hardiness and good health).
- Litter size/Kit survival (survival is enhanced in small to moderate size litters).
- Body condition (vital to maintain while doe regularly produces litters [maximum of 4 litters/annum in adverse environments]).
- Moderate milk production (risks of mastitis is presumably reduced if stock is not selected for high milking ability).
- Slow to moderate growth rate (reduced risk of Enteritis/ Enterotoxemia is usually observed in fryers fed on high fiber/low energy diets on small farms).

physiologically sound in many regards as these qualities pertain to growth to mature body size, level of reproduction, and general adaptation (table 2). Qualities such as ear length, fur density, fertility during hot months, forage intake capacity, etc., may have real merit as potential selection critera as opposed to traditional selection measures of production (*e.g.,* litter size and growth rate). Research in this area is obviously needed.

Also, in such a population (local or heterogeneous) it would be possible to sample rabbits from villages for restocking in the catastrophic event that the nucleus stock at the breeding station was lost. Logistically, and where appropriate, this approach could enhance the security of long-term conservation efforts.

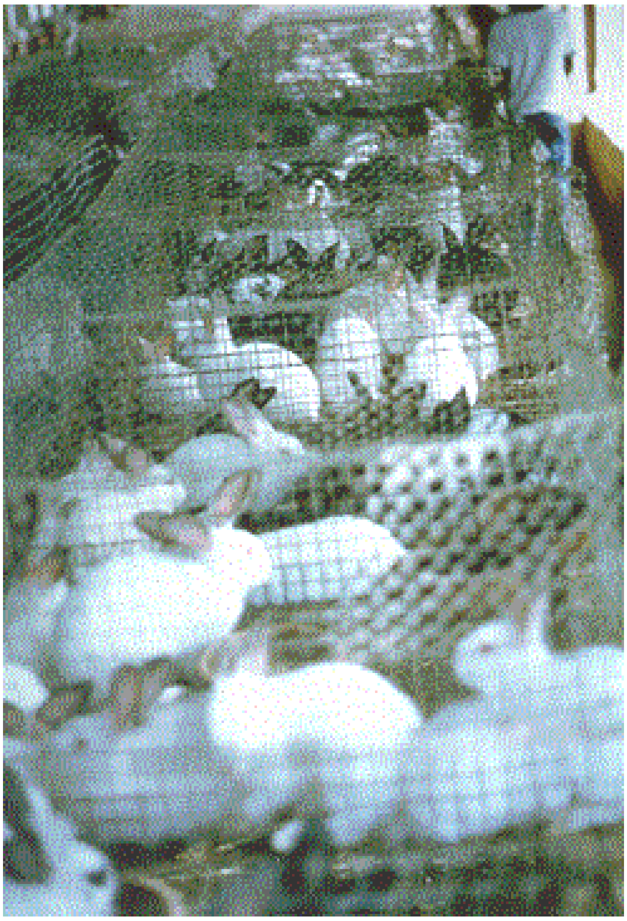

Figure 6. Dominican Republic. Predominate use of exotic breeds in a commercial rabbitry near Santo Domingo.

Facility and Resource Constraints

A major constraint in the LDC's is limited facilities, or lack of breeding infrastructure, to properly maintain closed and sufficiently large straightbred populations. In many countries there are, in fact, serious resource constraints at breeding stations which would preclude direct involvements in conservation programs. One approach would be to designate only one country in a region with the best facilities, resources, and genetic expertise to maintain valuable breeds or strains (*e.g.*, Creole, Criollio, Japanese Large-eared, Kenyan White, and Soviet Chinchilla) as found in other contiguous countries. To reiterate, the option may exist to utilize local strains through a network of farmer leaders in a major rabbit raising region of the country, whereby this activity could lead to conservation.

In lieu of breeding stations, one option is to carry out conservation programs through the efforts of rabbit farmer leaders who represent villages in a given region. Generally, the care, feeding, and management of rabbits by experienced breeders on small farms is usually better than conditions at major breeding stations where worker incentives, feed shortages, budget constraints, *etc.*, can often be a problem. Also, exchanges of breeding stock takes place more readily amongst farmers (between and within villages or communities) than between breeding stations and farmers. Of relevance, the involvement of women project leaders is especially encouraged as there have been many such successful rabbit projects (Lukefahr, 1988b; Finzi and Amici, 1991). However, while this field-based conservation approach has its advantages, good project organization and co-ordination would be essential, and such a program would require the official approval by participating governments.

Genetic Research Priorities for Limited-Resource Rabbit Farmers

It is most unfortunate that there is a paucity of research studies that have determined the most appropriate genetic stocks for usage by limited-resource farmers. Studies from the LDC's, invariably, took place at government breeding stations or at large commercial farms where conditions are considerably different from those found in villages at the level of small-scale farmers. Further, standard breeds are typically found at the former whereas non-standard breeds (local strains) and/or crossbreds are often found in villages.

Table 3. Comparative studies involving exotic and local breeds and crosses conducted in tropical and arid regions.

Country breed*	No. of rabbits	LSB	SR	AWW	ADG	MW	Reference
				Trait**			
Benin	161						Kpodekon *et al.* and Lebas *et al.* (1996)
NZW		-	-	.37	19.4	1.49	
L		-	-	.41	23.4	1.79	
Egypt	261						Rashwan et al. (1997)
Baladi Red (BR)		5.6	.43	.34	14.1	1.13	
Baladi Black (BB)		6.1	.49	.54	16.4	1.45	
NZW		4.4	.77	.51	14.5	1.31	
NZW X BR		4.9	.65	.34	18.9	1.39	
NZW X BB		6.1	.65	.43	19.2	1.50	
Guadelupe							Matheron and Dolet (1986)
Creole		6.6	.68	-	-	-	
NZW		7.4	.69	-	-	-	
India	168						Sundaram and Bhattacharyya (1991)
SC		7.0	.71	.42	19.3	2.00	
L		4.6	.87	.44	12.9	1.50	
SC X L		5.2	.94	.35	16.8	1.73	
Malaysia	435						Sangare and Ariff (1995)
CAL		6.7	.46	.46	-	-	
Rex		5.6	.42	.42	-	-	
L		5.2	.52	.40	-	-	
CAL X L		6.2	.59	.48	-	-	
Rex X L		6.3	.55	.41	-	-	
Sudan	***						El Amin (1978)
Baladi		4.7	.85	.31	-	1.31	
CAL		7.1	.75	.68	-	3.79	
NZW		7.5	.74	.60	-	3.31	

* Breeds: NZW = New Zealand White; L = local breed; SC = Soviet Chinchilla; CAL = Californian.

** Traits: LSB = litter size born; SR = survival rate; AWW = average weaning weight, kg; ADG = postweaning average daily gain, g/d; MW = market weight, kg. Across studies, the AWW was recorded between 28 and 31 days (age was not specified in the Sudanese study). The MW was recorded at 84 days, 87 days, 112 days, and at maturity in the studies from Egypt, Benin, India, and Sudan, respectively. The SR measure involved preweaning survival in the reports from Guadelupe, India and Sudan, and postweaning survival in the report from Egypt.

*** Number of rabbits involved in the study was not reported.

Figure 7. Indonesia. Opportunity for on-farm research to compare breeds. Exotic and local rabbits together in a small rabbitry. (Courtesy of P.R. Cheeke).

Few reports are available involving comparisons between exotic and local breeds and their crosses, none of which took place on small farms (table 3). In contrast, there are many more reports (too numerous to include in this report) which compared only exotic breeds at breeding stations in the LDC's for potential use in commercial operations. Only one report from Egypt is presented in the table, although there have been numerous such studies reported from this country. One novel experiment by Kpodekon *et al.* (1996) and Lebas *et al*. (1996) involved the comparison of NZW to a local strain in Benin, whereby the latter genotype had significantly heavier weaning and 87-day final weights and achieved more rapid pre- and post-weaning gains. Interestingly, the study involved a French shipment of NZW neonates which were fostered to litters reared by local does in Benin. The study was conducted at a breeding station under semi-commercial conditions.

To date, results from such breed evaluation studies are inconclusive, except that breeds which bear smaller litters tend to have higher survival rates. Although the NZW was developed in the hot environment of southern California, and while in some studies (Matheron and Dolet, 1986; Kpodekon *et al.*, 1996) this breed has appeared to perform relatively well, it was not selected for adaptation to subsistence conditions on small farms. Moreover, it is difficult, perhaps even inappropriate, to make broad (across country) comparisons between local and exotic breed populations because even country populations of the same breed could be unique and also environmental and/or local conditions could vary greatly. Studies which show local breeds to be less productive than exotic (commercial) breeds does not necessarily mean that there is room for genetic improvement. Local breeds have adapted to be less productive under adverse

Figure 8. Ghana. Local doe with Flemish Giant-sired litter at the National Rabbit Project, Kwabenya. Note growth potential and large ears of kits.

Figure 9. Ghana. Poor genetic adaptation of imported New Zeland White rabbit at a remote project village site.

environmental conditions as found on small farms. The rearing of a large and rapid growing litter on a poor quality diet could be devastating to a local doe and her litter! Adoption of the use of commercial breeds may not be appropriate for reasons of economy of scale (*i.e.,* inexpensive diet of poor quality, low nutrient requirements, rustic housing, and no hired skilled labor). While commercial breeds certainly possess genes for production, they may lack essential genes for trait functionality (table 2).

A research priority is to test the relative performance of rabbit breeds and strains, exotic and local, under small farm conditions. Traits pertaining to functionality as well as productivity should be closely monitored. Better feeding and management may be essential to support exotic breeds, which in some cases may not be justified.

Of relevance, the author has assisted private voluntary organizations in arranging overseas shipments whereby exotic breeds were directly placed on selected farms in several villages where local stock were also present. This approach was preferred over sending exotics to breeding stations where conditions in some cases were known to be deplorable, and where there was little exchange between researchers and farmers. Farmers kept production sheets to collect information on breeds and crosses, although the sample size has been usually too small to draw major conclusions about the suitability of breeds or crosses. The challenge is to design or carry out projects that involve adequate numbers of small-scale farmers who keep basic production records on breeds or strains of rabbits whereby valid comparisons could be made. Such a useful study which evaluated CAL, NZW, and crossbred stock was conducted on 110 farms in Poland as reported by Brzozowski *et al.* (1998).

Figure 10. Lithuania. Traditional colony-rearing, winter hay feeding, and maintenance (non-reproduction) of tractable, mature local rabbits protected inside a farm building (Courtesy of S. Janavicius).

Conclusions and Recommendations

This paper has addressed a number of issues that relate to the identity and management of global rabbit genetic resources. The salient points of this paper are as follows:

- Indigenous rabbit breeds with major adaptation merits may only be found in Europe and the Mediterranean region from a geographic as opposed to a socio-economic context.

- Data bank descriptions should reflect the distinction between productivity of standard breeds versus functionality of non-standard breeds or strains.
- Breeds or local strains that possess truly unique genotypes of merit for fitness and production characters should receive priority as candidates for conservation.
- A country's repertoire of commercial and fancy breeds should at least be characterized and inventoried in the documentation stage of data bank processing.
- Shortages of exotic breeds in LDC's, or lack of breeding infrastructure, have often led to inbreeding or outcrossing to other breeds or strains which may complicate the task of identifying genuine breeds or unique genotypes and of detecting the precise cause of genetic diversity.
- Shipments of exotics oftentimes involve small numbers of breeding animals which can promote inbreeding.
- Facility and resource constraints and lack of breeding infrastructure at breeding stations may preclude direct involvements in rabbit breed evaluation or conservation programs.
- One country in a region with the best facilities and resources could possibly maintain valuable breeds or strains as opposed to duplicative efforts in contiguous countries.
- In the LDC's there appears to have been little incentive to develop new and more adaptable breeds, and there is limited evidence that genetic selection efforts have been effective.
- A high degree of heterozygosity might possibly enhance local adaptation for fitness-related characters under adverse environmental conditions, such as in tropical and arid regions.
- Qualities such as ear length, fur density, fertility during hot months, etc. (functional traits), may have merit as potential selection critera, especially in regions with adverse environments.
- Heterogeneous (locally adapted) populations utilized by farmers may be more acceptable for inclusion in genetic resources data banks and for conservation than attempts to reintroduce, identify or conserve exotic straightbreds or to develop new breeds at breeding stations.
- The suitability of exotic breeds performing under adverse environmental conditions at the limited-resource farmer level is questionable based on project cases, although literature reports are not available.
- A research priority, and an obvious challenge, is to test the relative performance of rabbit breeds and strains on small farms under limited-resource conditions.
- In conclusion, rabbits have a unique niche to inexpensively produce food and fiber for rural families, especially in the LDC's. Hence, it is imperative that global rabbit genetic resources management programs continue to focus especially on breeds or local strains that are typically utilized under small-scale and limited-resource conditions. Utilization by farmers is just as or is more important than conservation. Oftentimes, utilization is the only practical means of conservation. In some cases, conservation programs might even be appropriately and effectively conducted in the field under small-farm conditions.

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