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RABBIT PRODUCTION IN LOW-INPUT SYSTEMS IN AFRICA: SITUATION, KNOWLEDGE AND PERSPECTIVES – A REVIEW[1]

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Abstract: High poverty levels continue to plague much of Africa despite several intervention strategies aimed to stem the tide. The role of small livestock like rabbits as a tool in poverty alleviation programmes has been acknowledged for decades and successful national rabbit projects have clearly been demonstrated in Africa. With rising poverty levels across Africa, the need to rejuvenate such national rabbit projects for long-term sustainability becomes apparent. This presentation focuses on the status of rabbit production in Africa, with special attention to smallholder rabbit project development and its connection with poverty alleviation issues in the continent and with an emphasis on the strengths, weaknesses, opportunities and barriers to the system. A special case is made for the sustainable development of smallholder, low-input rabbit production systems in Africa on account of their popularity, low investment requirements and low economic risks, as well as their contributions to family nutrition, income generation and gender empowerment. Successful rabbit projects in several countries across Africa were identified and the reasons for success, as well as lessons learned, are discussed. In all, several cases standout: the National Rabbit Project of Ghana, the Heifer Project International Rabbit Project in Cameroon, and CECURI Rabbit Project in Benin Republic. Other fast-paced and moderately developed rabbit industries (e.g. in Egypt, Tunisia and Algeria) are recognised. Critical constraints to rabbit project development (e.g. non-implementation of sustainable models for low-input rabbit units and absence of client-focused research and development programmes) are noted. Prospects for the development of sustainable smallholder rabbit production models are discussed, which include the following: a paradigm shift among researchers to focus on innovative research related to the development of sustainable backyard rabbit production systems; upscaling of sound practices in smallholder rabbit units across regions; use of local value chains in smallholder rabbit development and setting up regional networks of smallholder family rabbit projects. The actualisation of these goals requires a sustainability research agenda that focuses more on backyard rabbit farmers as the primary beneficiaries. Overall, the need for a poverty focus and a pro-poor research agenda involving owners of backyard rabbits are emphasised.

Key Words: rabbits, research and development, smallholder units, low-input systems, poverty alleviation, Africa.

INTRODUCTION

For several decades, Africa has been plagued by high poverty levels that have portrayed an increasingly worrisome trend over time. According to a World Bank report (World Bank, 2008), between 1993 and 2002, people living below the poverty line ($1-a-day) in Sub-Saharan Africa (SSA) increased from 200 million to 220 million in rural areas and from 80 to 100 million in urban areas. This report noted that the number of rural poor has continued to rise and will likely exceed the number of urban poor by 2040. Across the continent, country profiles by the Central Intelligence Agency (CIA) have revealed that over a 12-year period, poverty levels in SSA ranged between 28 and 80% of the entire populace (CIA, 2012). These reports noted that overall, poverty levels are very high in

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the continent with differences between regions (e.g. North *vs.* Sub-Saharan Africa) or by location within countries (e.g. rural *vs.* urban areas, World Bank, 2008).

Small livestock species, including rabbits, have been promoted as tools for poverty alleviation programmes (Dolberg, 2001; Owen *et al.*, 2005). For over 3 decades now, the contribution of smallholder rabbit units to food security in developing countries has been clearly recognised (Owen, 1976; Cheeke, 1986; Lukefahr and Cheeke, 1991a). Rabbits are particularly favoured for poverty reduction programmes on account of their low investment and early benefits, and subsistence on renewable resources for feeding, housing and general management. Thus, small-scale rabbit projects could be used as a vehicle for the poor to help themselves (Lukefahr, 1999a). A projected 5-yr budget plan for an initial 3-doe operation for a typical rabbit farmer in Cameroon illustrated the low investment costs involved in small-scale subsistence rabbit enterprise (Lukefahr and Cheeke, 1991a). The model could later be easily expanded to 5- to 10-doe operations in order to achieve a major favourable impact for the target family.

Several reports have established favourable impacts of rabbit development projects in terms of: (a) poverty alleviation (Cheeke, 1986; Lukefahr, 2000; Owen *et al.*, 2005); (b) rural development (Kpodekon and Coudert, 1993; Kpodekon *et al.*, 2000); (c) reducing rural-urban migration (Kamel and Lukefahr, 1990); (d) entrepreneurial skills (Kaplan-Pasternak, 2011); (e) humanitarian services including recovery efforts from natural disasters (Kaplan-Pasternak and Lukefahr, 2011); and (f) gender empowerment (Lukefahr *et al.*, 2000).

The support of global organisations and foundations for rabbit research and development (R&D) has been ongoing for several decades now. Of special interest is the support provided by the Food and Agriculture Organisation (FAO) of the United Nations for rabbit projects in several developing countries, including Tunisia (Belli *et al.*, 2008). Also noteworthy is the support provided by the International Foundation for Science (IFS, Stockholm, Sweden) for young scientists in the developing world for R&D programmes that support efforts towards poverty alleviation. In 1978, the IFS sponsored an international workshop on rabbit husbandry in Africa. The event was held in Morogoro, Tanzania, in conjunction with the Tanzanian National Scientific Research Council. Presentations at the conference included classic papers on rabbit production in tropical countries, methods of smallholder rabbit production, rabbit health, reproduction and housing and country reports from Tanzania, Sudan, Mozambique, Togo, Ghana, Zambia, Mauritius, etc (IFS, 1979).

However, in spite of these efforts, the extent to which small-scale or backyard rabbit projects can make sustainable, long-term contributions to poverty reduction and gender empowerment remains hazy. This fact is corroborated by the rising poverty level in SSA, in spite of several intervention strategies attempting to stem the tide and improve family welfare. Thus, this presentation investigated the status of rabbit production in Africa, with special attention to smallholder rabbit project development and its connection with poverty relief.

Characteristics of, and opportunities provided by smallholder rabbit units

Rabbits were most probably first introduced to countries in SSA well over 100 yr ago by the early European Colonists and/or American and European missionaries, likely followed by a long period of repeated stock introductions (Lukefahr and Cheeke, 1991a; Lukefahr *et al.*, 2000). Small family rabbit units averaging four does or less, based on local resources for feeding, housing, and healthcare, are the usual pattern in many parts of the less developed world (Lebas *et al.*, 1997; Onifade *et al.*, 1999; Oseni *et al.*, 2008). Present strategies to develop small-scale backyard rabbit enterprises have been described as an 'alternative back to basics' approach (Lukefahr, 1999a). This author noted that such downscaled units could represent a more favourable economy of scale of production based on the use of renewable farm resources. Lukefahr (1999) moreover, reported that most farmers in less developed countries live under limited-resource conditions of land, feed supplies, equipment and capital. In this context, the promotion of commercial animal production enterprises may not be appropriate for such farms because it can subject them to considerable economic risk (Udo, 1997, cited by Lukefahr, 1999a).

At this juncture, it is pertinent to define and explain "low-input farming systems" (LIFSs). Poux (2008) defined LIFSs as "those that maximise the use of *on-farm* inputs or resources when compared to high input farming systems that rely more on *off-farm* bought inputs". According to this author, the physical productivity of LIFSs is limited by the maximum (availability of) *on-farm* resources that can be mobilised, noting therefore that LIFSs are associated with lower outputs. Furthermore, according to Parr (1990, cited by Poux, 2008), LIFSs seek to "optimise the management and use of internal production inputs (i.e. *on-farm* resources), minimise the use of *off-farm* resources whenever and wherever feasible and practicable, in order to lower production costs and reduce a farmer's overall risks…" With respect to backyard and smallholder rabbit units, the definitions above are in harmony with the small-scale rabbit production model (SSRPM) proposed by Lukefahr (2004) that emphasises alternative and self-sustaining systems for small-scale rabbit production where inputs are sourced within the farm. The SSRPM, according to the author, is designed to meet the forecast of increasing pressures on natural resources and greater demands for food for the rising human population.

According to Finzi (2000), smallholder rabbit units are characterised by the following: (a) few breeding rabbits in backyards; (b) use of local materials for hutches and equipment; (c) feeding of fresh forage and kitchen wastes; (d) integration of rabbits with other farm components; (e) sharing of family labour, (f) consumption of rabbits by the household or through sale of excess stocks in the local market. Finzi (2000) also noted that smallholder rabbit units, although lacking in economic resources, have available as assets both family labour and traditional knowledge of raising small livestock. This author therefore recommended the need for applied research that supports the development of rabbit cottage industries.

Colin and Lebas (1996) observed that rabbit production is relatively important to the economy of some developing countries like Nigeria, Egypt, Ghana, Morocco, and Cape Verde. These authors noted that traditional farms with 8 to 10 does that are oriented towards family consumption and based on renewable resources constitute 64% of farms in SSA and 58% in North Africa. Moreover, the percentage of does on traditional farms in North Africa and Sub-Saharan Africa is estimated at 67 and 76%, respectively. These figures are high and provide a further justification of the need for client-focused R&D for long-term sustainability of these units. More recent reports from the FAO (FAOSTAT, 2011) indicated that between 1990 and 2010, some countries (e.g. Botswana, Burundi, Cameroon, Egypt, and Gabon) reported modest increases in national rabbit stocks (breeding females) from 15 to 41%; other countries (e.g. Kenya, Madagascar, Rwanda and Sierra-Leone) showed exponential increases of 145, 130, 172 and 407% respectively. Stock numbers were static for Algeria and declined in Mauritius (Table 1). A similar trend for rabbit meat production quantity (in tonnes) for these countries is presented in Table 2 (FAOSTAT, 2011).

In Egypt, Kamel and Lukefahr (1990) reported that village rabbit projects that directly involved young people reportedly decreased the rate of youth migration to urban areas. Small-scale rabbit projects have also targeted the more vulnerable households (e.g. people living with HIV/AIDS or recovery programmes from natural disasters like the devastating earthquake in Haiti in 2010, as reported by Kaplan-Pasternak, 2011; Kaplan-Pasternak and Lukefahr, 2011). In addition, Lukefahr (1999a) reported that small-scale rabbit production provides opportunities as humanitarian projects that assist people who live in poor rural communities.

Table 1: Rabbit breeding females (thousands) for selected countries in Sub-Saharan Africa over a 20-yr period (FAOSTAT, 2011).

	Year			
Country	1990	2000	2005	2010
Algeria	1400	1400	1400	1400
Botswana	100	100	100	120
Burundi	110	50	100	135
Cameroon	38	47	48	48
Egypt	6591	7300	7350	7300
Gabon	270	300	300	310
Kenya	214	313	472	525
Madagascar	50	120	110	115
Mauritius	15	15	7	5
Rwanda	292	339	519	793
Sierra-Leone	-	300	1350	1520

Table 2: Rabbit meat production quantity (tonnes) for selected countries in Sub-Saharan Africa over a 20-yr period (FAOSTAT, 2011).

	Year			
Country	1990	2000	2005	2010
Algeria	7000	7000	7000	7000
Botswana	900	900	900	990
Burundi	436	184	396	516
Cameroon	76	94	96	96
Egypt	49020	54240	54840	54600
Gabon	1620	1992	1800	1860
Kenya	1284	1860	2820	3000
Madagascar	300	720	660	690
Mauritius	81	81	38	25
Rwanda	1152	1332	2034	2040
Sierra-Leone	-	1500	6750	7500

LIMITATIONS TO RABBIT PRODUCTION IN AFRICA

Major Constraints

Key constraints to the development of a viable rabbit industry in Africa range from institutional and policy limitations that hinder the development of sustainable programmes for smallholder rabbit units to critical environmental conditions (e.g. heat stress, poor stock adaptation and poor diet quality). In particular, institutional limitations include lack of appropriate policy framework for small stock development that supports backyard and smallholder rabbit production systems. Related to this is the dearth of meticulous strategies for the development of smallholder rabbit units with a clear poverty alleviation focus. It is apparent that the contributions of rabbits to household nutrition, income generation and food security are not recognised. Such unique contributions of smallholder rabbit production units were documented in Adu *et al.* (2005). In spite of these limitations (i.e. absence of a policy framework for small stock development), evidence abounds of efforts at self-mobilisation by rabbit farmers that have yielded good results. Reports from Ciskei, South Africa (Zeising, 2000) and Guerrero State, Mexico (Clavel *et al.*, 2004) provide good examples. These reports showed that farmers can develop sustainable backyard systems of rabbit keeping, even without technology or technical assistance and with a minimum capital investment. These are proven cases of communities that have developed economically sustainable and environment-friendly smallholder rabbit production systems that have helped poor families in marginal lands.

Environmental constraints mainly include adaptation to heat stress and/or slow growth rate as a result of a multitude of factors including sub-optimal management, inadequate nutrition, inappropriate housing design, etc. Heat stress poses a serious limitation to rabbit production in the tropics (Savietto *et al.*, 2012; Cherfaoui *et al.*, 2013; Kumar *et al.*, 2013; Sivakumar *et al.*, 2013). High ambient temperatures, in fact, can cause infertility in breeding rabbits and 30°C is considered the threshold beyond which infertility may likely result (Lebas *et al.*, 1986; Lukefahr and Cheeke, 1991b). Adaptation to heat stress, particularly under hot and humid zones, was extensively reviewed by El-Raffa (2004). This author noted that heat stress was ranked as the most important problem facing the rabbit industry in the tropics and in arid regions, as compared to poor quality diets, diseases and/or parasites. El-Raffa (2004) also noted that heat stress reduces feed intake, impairs growth, decreases fertility and increases kit mortality. Furthermore, Finzi *et al.* (1992) evaluated heat stress under field conditions and reported that animal posture (which varied from 'normal', 'active' or 'stretched' positions) gave some indication of the degree of heat stress in rabbits. Of course, more precise measures such as core body temperature, pulse and respiration rates are also useful. In spite of the harsh and depressive effects of heat stress on rabbit performance in hot and humid climates, it is notable that rabbits are successfully raised in such climates and still make meaningful contributions to family nutrition and welfare. Several suggestions to protect rabbits from extreme heat stress, including appropriate housing design and placement or mating of animals in the early hours of the day, among other practices, have been recommended (Lukefahr and Cheeke, 1991b; Lebas *et al.*, 1997; Finzi, 2000).

Slow growth rate of rabbits with average daily gain (ADG) values ranging from less than 10 to 21 g/d is typical in tropical regions, compared to 35 to 40 g/d as recorded in temperate countries (Lukefahr and Cheeke, 1991a). In Nigeria, Odeyinka *et al.* (2008) reported pre-weaning ADG values of 7 g/d. For post-weaning growth, Onwudike *et al.* (1995) reported some promising results in ADG values of 21.2, 13.8, and 18.4 g/d, respectively, for rabbits fed *Gliricidia* compared to *Leucaena* and a control diet (consisting of pelleted concentrate fed alone without supplemental foliage). Moreover, in Egypt, Rashwan *et al.* (1997) compared prolificacy and pre- and post-weaning growth performance of 7 rabbit genotypes during hot summer months in Egypt. Genotypes evaluated by these authors included New Zealand White (NZW), Baladi Black (BB), Baladi Red (BR) and reciprocal crosses between NZW and BB, and NZW and BR. Results from this study showed that pre-weaning ADG ranged from 10.2 to 17.4 g/d and 9.1 to 14.0 g/d for the pure breeds (NZW, BB and BR) and crossbred groups, respectively, while post-weaning ADG ranged from 17.5 to 19.4 g/d and 14.1 to 16.4 g/d for pure breeds and crossbred groups, respectively. Causes of such low ADG values were primarily credited to heat stress and poor diets. This constraint underscores the importance of suitable diets and heat stress mitigation strategies for smallholder units, as documented by Finzi (2000).

Other limitations to rabbit production in Africa include the absence of a tradition of eating rabbit meat in some locations in SSA. This can be countered through promotional strategies like rabbit fairs and field days and through cooperative marketing of stocks (Price and Regier, 1982; Oseni, 2010).

SUCCESS STORIES OF RABBIT PROJECT R&D IN AFRICA

Success Stories

For over 4 decades, several success stories involving the implementation of R&D projects with large numbers of smallholder backyard rabbit units have been recorded all across Africa. Notable examples of these include: (a) CECURI Rabbit Project of Benin Republic (Lebas *et al.,* 1997; Kpodekon and Coudert, 1993); (b) Heifer Project International, Cameroon (Lukefahr *et al.*, 2000); (c) National Rabbit Projects of Egypt (Kamel and Lukefahr, 1990; Galal and Khalil, 1994), (d) the National Rabbit Project of Ghana (Mamattah, 1979; Lukefahr, 2000); (e) National Rabbit Fair in Kenya (Kamande, 2010; Oseni, 2010); (f) Malawi (McNitt, 1979); (g) Mauritius (Ramchurm, 1979); (h) Mozambique (Gaspari, 1979; Demeterova *et al.*, 1991); (i) Rabbit project in Ciskei, South Africa (Zeising, 2000); (j) FAO and Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) support for rabbit project development in Tunisia (Belli *et al.*, 2008), and (k) Rabbit projects in Uganda (Lukefahr, 1998b).

Several of these national projects gained global prominence on account of their remarkable successes, either as a result of the number of people impacted by the project (National Rabbit Project of Ghana; Heifer Project International in Cameroon, and the CECURI project of Benin Republic) or through project replication (e.g. Heifer Project International in Cameroon). Some of these projects or programmes are discussed briefly below.

(a) The CECURI project of Benin Republic. The CECURI project was set up to vitalise the rabbit production sector, where the promoters emphasised the need for local solutions to feeding, genetics and housing challenges (Kpodekon and Coudert, 1993; Lebas *et al.*, 1997). The goal of the project was to raise awareness and knowledge about rabbit production, breeding, pathology, etc, in order to improve local production and to extend a suitable method for its rearing. According to Kpodekon and Coudert (1993), some of the impacts of the project included: (1) increased number of scientists involved in rabbit R&D; (2) increased number of smallholder rabbitries; (3) creation of a rabbit breeding association in Benin Republic, and (4) establishment of a functional R&D centre to provide client service to backyard rabbit units.

(b) The Heifer Project International-Cameroon Rabbit Project (or HPI-CAM). Lukefahr and Goldman (1985) and Lukefahr *et al.* (2000) described the HPI-CAM project for farm families that had the goal of improving family nutrition and income, and also enhancing community development and gender status in villages in Cameroon. The project involved appropriate local technologies and the use of renewable *on-farm* local resources. The project has been described as a role model in developing rabbit projects in other Lesser Developed Countries (LDCs) by the HPI.

(c) From Egypt, several reports of rabbit projects are noted. Galal and Khalil (1994) reported on the National Rabbit Project of Egypt, which involved collaboration between Zagazig University in conjunction with the Egyptian Academy of Scientific Research and Technology. The breeding objective involved the distribution of purebred Californian and New Zealand White rabbits, along with an extension package to facilitate project uptake and adoption by small-scale rabbit farmers. A second 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 soft loans. Both projects documented good successes. A third project reported by Kamel and Lukefahr (1990) was a comprehensive and integrated project involving rural development in Ezbet Badir supported by the Near East Foundation. The approach was a participatory and community-based development project managed at grass root level. The project also recorded some remarkable successes, which according to the authors included stemming the tide of rural-urban migration among the youth and literacy improvement.

(d) The National Rabbit Project (NRP) of Ghana, which according to Mamattah (1979), and Lukefahr (2000) was a widely recognised programme and for decades served as a model for lesser developed countries as a means to alleviate national meat shortages and increase farm income. The programme provided breeding stock, training and extension support to limited-resource farmers. These authors reported that the NRP for many years served as a role model to other developing countries in terms of government's role and duty in feeding its people through sustainable smallholder rabbit production.

(e) The National Rabbit Fair of Kenya (Kamande, 2010; Oseni, 2010) involved some 2000 smallholder rabbit farmers, as well as key stakeholders, including micro-finance and input suppliers and services (e.g. veterinarians and feed millers). The goal was to sensitise the populace about the contributions of smallholder rabbit production to income generation and diversification, employment and family nutrition.

(f) The Rabbit Research Project at Bunda College of Agriculture, Malawi (McNitt, 1979). The project focused on nutrition, animal care, housing and general management. The project was initiated specifically to investigate the requirements and needs of smallholder rabbit producers with respect to housing, health-care, nutrition and breeding stock.

(g) FAO and CIHEAM support for rabbit project development in Tunisia (Belli *et al.*, 2008). These authors reported that, in the last 20 yr, rabbit breeding in Tunisia has developed and continues to do so with the introduction of new technologies and continued government support, including support from international organisations such as the FAO of the United Nations, and with initiatives such as the International Observatory on Rabbit Breeding in Mediterranean countries and the CIHEAM.

(h) National programme of rabbit production in Mozambique (Gaspari, 1979; Demeterova *et al.,* 1991). These authors reported on the successful implementation of a national rabbit production programme in Mozambique. The project was implemented through a national centre and several provisional centres - to provide housing, breeding stock and training facilities for the populace with a strong emphasis on renewable resources (especially forages) for feeding rabbits.

Lessons learned

Some of the major lessons learned from these aforementioned projects include the following: (1) a functional R&D rabbit centre contributes significantly to project success (Kpodekon and Coudert, 1993); (2) the projects are largely focused on the special needs of smallholder rabbit units; (3) gender empowerment could also be achieved through backyard rabbit projects (Lukefahr, 2000; HPI-CAM project); (4) small-scale rabbit projects could be used as a tool for the enhancement of family welfare (Mamattah, 1979; Owen, 1979; Cheeke, 1986; Kpodekon and Coudert, 1993); (5) R&D projects involving multiple stakeholders (e.g. researchers, non-governmental organisations (NGOs), government agencies, farmers, etc) can lead to enhancements involving family welfare with positive impacts on potentially thousands of resource-limited families in the developing world; (6) the synergy resulting from collaboration among stakeholders has been instrumental in ensuring project success; (7) the role of the government is pivotal to the success of such development projects; (8) all the projects served as models for the use of small livestock as vehicles for family welfare, gender empowerment and poverty reduction, (9) continuing the momentum long after the formal lifespan of a project remains a challenge (a point well appreciated in development work). In other words, the long-term sustainability of a project remains a challenge.

R&D MODELS INVOLVING RABBITS

R&D Models in Rabbit Project Development

R&D models serve as the basis for linking research output in rabbit science and production to sustainable development, including programmes related to poverty reduction and gender equity. Several R&D models used in the development of smallholder rabbit projects include the Heifer Model (Aaker, 2007; Bhandari, 2008) and the Small-Scale Rabbit Production Model (or SSRPM, Lukefahr, 2004), among others. These models serve to link livestock projects as tools for community development, poverty alleviation and gender equality.

In particular, the Heifer Model (HM) has been described as a values-based development tool to help rural community-based organisations assess, plan, manage and monitor smallholder livestock project development (Aaker, 2007). The HM was further described as a people-centred community development model using livestock as an integral component (Bhandari, 2008). This author noted that this innovative approach has helped millions of people for more than 60 yr, in over 125 countries, and contributed to enhanced family livelihoods, increased household food security and improved family nutrition without exploiting their natural resource base. A principal example with the HM in the successful implementation of rabbit development project is the Heifer Project International - Cameroon Rabbit Project described previously under “success stories” above. The goal of the project was to improve family nutrition and income, and also enhance community development and gender status in villages in Cameroon (Lukefahr and Goldman, 1985; Lukefahr, 2000).

The SSRPM proposed by Lukefahr (2004) represents an alternative and self-supporting system based on renewable farm resources for the development of small-scale rabbit projects as the basis for poverty reduction. According to this author, the SSRPM is a development planning tool that rests on 3 tiers: (a) external factors (e.g. ecological, economical and sociological aspects); (b) intermediate factors (e.g. project feasibility, design, implementation, monitoring and evaluation), and (c) internal factors (including genetics, housing and equipment, diet and health management). Thus, the SSRPM addresses critical requirements for the successful initiation and sustainability of small-scale rabbit projects especially designed for limited-resource farm families in the developing world. Lukefahr (2004) called for a novel line of “sustainability research” to evaluate the SSRPM factors (internal, intermediate and external) under local situations.

R&D strategies for smallholder rabbit units

The goals of R&D programmes involving rabbits are to boost knowledge, recognition and awareness of smallholder rabbit production as a key strategy in poverty alleviation, household food security and empowerment of women. It is widely acknowledged that R&D programmes could play a pivotal role in realising these lofty goals (Lebas *et al.*, 1997; Bang, 1999; Finzi, 2000; Conroy *et al.*, 2002; Lukefahr, 2002; Morand-Fehr *et al.*, 2004). Finzi (2000) noted that research has been addressed exclusively to improving industrial (livestock) systems that are largely unsustainable in LDCs. Thus, the need for research relating to alternative and sustainable systems is apparent.

The role of researchers and their contributions to the development of sustainable small-scale rabbit projects was emphasised by Lukefahr (2007). According to this author, a dynamic and viable rabbit breeding industry depends on a cadre of rabbit scientists who engage in research activities that directly solve farmers’ problems. Similarly, Bang (1999) argued that researchers must focus their attention on the needs of poor farmers and recommended re-training opportunities for researchers on participatory *on farm* research design and implementation. In this regard, a paradigm shift on the part of rabbit scientists and other stakeholders is evident. In line with this observation, Lukefahr (2002) called on rabbit scientists to “retune their research priorities to develop local rabbit production systems that yield higher outputs at lower inputs involving limited *off-farm* purchases that would supply inexpensive meat for the family, improve farm productivity, and supplement income through the sale of surplus stock”. This author called on rabbit specialists to provide their valuable expertise to offer opportunities for small-scale rabbit farming and to share project experiences through publications. Even the constitution of the World Rabbit Science Association (Article 3: Objects, Number 3) emphasises “the dissemination of knowledge pertaining to all segments of the rabbit industry”. Lukefahr (2002) provided examples of research projects for small-scale rabbit production where specific expertise is needed to include the following: (a) suitable farm diets that could largely replace commercial pellets and guarantee *on-farm* feed security; (b) local remedies for treating diseases including mange, sore hocks, coccidiosis, diarrhoea, etc, and (c) selection of local genetic stocks for novel traits related to adaptation or traits that have real merit under low-input, smallholder systems (e.g. forage intake capacity, thermo-tolerance and low nutrient requirements, etc).

The need to focus R&D efforts on resource-poor farmers was also echoed by Conroy *et al.* (2002) who noted that the accountability of scientists to such target groups has been almost non-existent. These authors observed that most research is discipline-based rather system-based, with researchers focusing on components rather than on systems. This was further corroborated by Oseni (2008) who reported that 80% of the publications in rabbit science from SSA were basic research output, unidisciplinary in nature and conducted largely under *on-station* conditions. This author also reported that over two-thirds of these papers needed further trials to adapt the technologies to existing conditions of backyard rabbit units. As a solution, Conroy *et al* (2002) suggested the creation of incentives for researchers who conduct innovative *in situ* research that are system-based and with a poverty alleviation focus. These authors noted that the conditions which influence the relevance of research to poor livestock keepers include the following: (a) encouraging *in situ* research and rewarding researchers whose work results in benefits to the poor; (b) researchers receive training on how to conduct pro-poor, participatory research and/or forge partnerships with NGOs, and (c) research has a gender-sensitive element. That is, researchers should work with women if they have main responsibility for livestock.

To reiterate, the need to evaluate research in terms of its potential application to smallholder livestock production units has been suggested. According to Morand-Fehr *et al.* (2004), there is the need to evaluate the applicability of research results to these target groups based on a scale of 0 to 3, where: “0” implies “research with no possible application”; “1” denotes “research outcome with eventual application after carrying out other trials”; “2” implies research with possible applications, and “3” implies research with direct application to conditions in smallholder livestock units. In line with this suggestion, Oseni (2008) noted that over two-thirds of rabbit research outputs in SSA belonged to categories “0” and “1” above (Table 3), which represents a very worrisome trend, on account of the high poverty levels in the region.

Some critical R&D questions in relation to smallholder rabbit project development include the following: (a) How are such projects designed to benefit resource-poor farmers? (b) What is the current status of smallholder rabbit units in SSA? (c) What are their strengths and weaknesses? (d) What are the challenges facing smallholder rabbit units? (e) What are the R&D requirements for such units? (f) What are the R&D options for sustainable smallholder rabbit project development?

Requirements for adoption of the SSRPM

As documented by Lukefahr (2004), the internal tier of the SSRPM addresses farmer’s needs in terms of local factors and decision making, which includes the following specific factors:

Nutrition

Rabbit nutrition and the assurance of *on-farm* feed security is crucial for the sustainability of smallholder rabbit units. Rabbit nutrition represents one of the internal factors for the development of SSRPM based on renewable farm resources (Lukefahr, 2004). Many parts of Africa are characterised by the abundance of biomass which can be exploited for use by backyard rabbit units. Lukefahr (2004) reported that a forage security plan (within a farm) helps to ensure year-round availability of feeds. The author noted that the composition of the diet invariably changes

Table 3: Distribution of research papers by the index of potential applicability of research (from Oseni, 2008, following Morand-Fehr *et al.*, 2004).

Index of applicability	Number of papers	%
0 (No possible application)	6	5.22
1 (More tests required)	78	67.83
2 (Possible application)	21	18.26
3 (Direct application)	10	8.69
All	115	100.00

over seasons as certain ingredients become more or less abundant, and recommended that training of farmers on methods to prepare a forage security plan is paramount. Other efforts have involved unconventional feeding techniques for rabbits in developing countries (Finzi and Amici, 1996). These authors described the manufacture and use of molasses blocks and crumbs of feeds for rabbits with particular attention to the developing world.

Samkol and Lukefahr (2008) noted that plants like water spinach, mulberry, cassava leaves and sweet potato vines are nutritious for rabbits. Since these crops are already grown by farmers, the authors suggested integrated crop-livestock models where the foliage of these crops is fed to rabbits, and consequently, minimise *off-farm* purchases for rabbit feeding by farmers. Other resources including the use of palm kernel cake (PKC), which is relatively cheap and available across seasons in some parts of SSA. The nutritive value of some of these available leguminous plants has been evaluated in rabbits (as *Pueraria phaseoloides*; Akoutey *et al.*, 2012), and potential natural antioxidants have been studied to alleviate heat stress in these regions (as pomegranate peel; Zeweil *et al.*, 2013). Orunmuyi *et al.* (2006) reported that PKC can be used up to 30% in a maize-soybean meal-based diet for weaner rabbits. Moreover, Finzi (2008) reported that for forage-based diets, appropriate and specific management must be studied and applied. This author observed that for rabbit nutrition, out of some 170 vegetal feedstuffs or by-products that are well-known for their nutritional qualities in developing countries, only about 10% are used by feed mills.

Genetics

The provision of suitable breeding stocks that are well adapted to backyard systems is a key requirement to the sustainability of such systems. The challenge for smallholder rabbit units is the desired genotypes that can perform under low-input systems characterised mostly by sub-optimal management. With respect to the desired genotypes for backyard systems, the following questions have been raised: (a) what are the desirable genetic stock(s) for low-input rabbit production systems in hot and humid climates?, and (b) what available genotype(s) are adapted to such conditions (e.g. low-input, backyard systems)? Attempts to produce adapted genotypes that can perform under the conditions in smallholder units have not received much attention and do not appear to be a priority (Lukefahr, 1998a).

As a potential solution, local breeds of rabbits, as well as heterogeneous stocks described as “non-standard breeds”, have received increasing attention (Lukefahr *et al.*, 1992; Lakabi *et al.*, 2004; Zerrouki *et al.*, 2004, 2007; Oseni and Ajayi, 2010). Zerrouki *et al.* (2004) noted that the utilisation of local genetic resources first requires characterisation of the population existing in the country. In line with this, the characterisation of a local Algerian rabbit breed (the Kabylian) was presented in reports by Lakabi *et al.* (2004) and Zerrouki *et al.* (2004, 2007). Other reports (Gacem *et al.*, 2008) noted that in a cooperative venture between INRA (France) and Institut Technique de l’Elevage, (ITEV, Algeria), a new synthetic strain was developed from the insemination of Kabylian does by fresh semen of bucks from the INRA2666 strain, to exploit heterosis and breed complementarity. More sophisticated breeding, including the development of multi-purpose synthetic lines and selection programmes for the development of synthetic paternal lines in Egypt and Saudi Arabia, were reviewed by Khalil and Al-Saef (2008).

Heterogeneous stocks represent the product of crosses of pure breeds of commercial rabbits and/or local rabbit breeds (Lukefahr, 1998a). These stocks are predominant in many backyard systems in Africa. Lukefahr (1998a) argued that the maintenance of heterogeneous populations that are locally adapted may have real merit in adverse environments. This author, citing Falconer and Mackay (1996), noted that a high degree of genetic variation and/or heterosis might be important for fitness-related characters (e.g. fertility and survival) as a means for eventual local adaptation. The author observed that local rabbits showed anatomical and physiological soundness, including small-to-moderate mature size (possibly to minimise nutrition stress), large ears in proportion to body size, thermo-tolerance, etc. Physiological soundness (Lukefahr, 1998a) included the following: (a) adaptability to the climate (e.g. normal pulse rate, respiratory rate and body temperature); (b) adaptability to sub-optimal diets (e.g. high forage intake capacity); (c) small-to-moderate litter size, and (d) body condition maintenance on local diets. This author also noted that qualities relating to anatomical and physiology soundness as exhibited by heterogeneous rabbits may have real merits as potential selection criteria under low-input systems.

In this regard, the use of heterogeneous stocks seems promising when compared to imported or exotic breeds, particularly when one considers the costs and logistics involved with breed importation, as well as the risk of disease transmission. A major concern with heterogeneous stocks is the problem of inbreeding, which has been identified as a production constraint, especially in locations where the same breeding animals are circulated among rabbit farmers. A solution to this is a process of buck exchange by farmers across different locations (Lukefahr, 2011). Thus, heterogeneous stocks may present ample room for improvement of smallholder and low-input systems on account of the following: (a) availability in many backyard systems in SSA; (b) adaptable to sub-optimal management conditions in such units; (c) although output is low (some 20 fryers per doe per year or less; Lukefahr and Cheeke, 1991a), there is opportunity for improvement through sustainable efforts as demonstrated by the CECURI rabbit project in Benin Republic (Kpodekon *et al.,* 1999) and the NRP of Ghana (Lukefahr *et al.*, 1992; Lukefahr, 2000). In this regard, heterogeneous stocks may represent an under-exploited genetic resource for smallholder units that will require further attention with respect to sustainable breeding programmes as the basis for providing client service in the form of suitable breeding stocks to these units.

In summary, the availability of suitable and well-adapted rabbit genotypes to smallholder rabbit production units is seen as a key aspect of client service delivery and will most probably contribute to the success of any rabbit project development. This step can be coordinated from a research and development institute, as is the case with CECURI (Kpodekon and Coudert, 1993) or from an international NGO (e.g. HPI rabbit project of Cameroon; Lukefahr *et al.*, 2000). The challenge is the long-term organisational structure needed to implement such a programme in order to secure sustainable smallholder rabbit project development.

Housing

The housing needs of backyard rabbit systems are another issue. Each producer uses whatever design that they deem fit, implying that there is no template design that is common among all the farmers. Figure 1 shows a wide array of such designs of rabbit houses in south-western Nigeria. Rugh (1979) presented a detailed description of different housing designs for rabbits across villages in Africa and listed some of the basic criteria for such designs in different locations and ecological zones across Africa. Specifically, this author described the wood and bamboo hutch commonly used in the forest areas and discussed alternative designs for the savannah region where bamboo and wood are difficult to obtain. Thus, the issue of prototype housing designs for backyard/smallholder rabbit units needs to be addressed. Such designs should not only provide comfort for the animals, but also enhance heat stress mitigation and strategies to minimise animal losses through predation and/or theft.

Healthcare

Healthcare needs of backyard rabbit systems remain a challenge. Proper documentation of the most common ailments or diseases of rabbits and their prevalence rates under backyard systems across different regions and seasons in SSA are needed. In addition, workable local remedies (where available) need to be documented as well. Semuguruka (1979) listed some diseases prevalent across farms in Tanzania, which included pasteurellosis, coccidiosis, enteritis, and salmonellosis. Aduma (1979) noted the connection between management practices and the occurrence of diseases (particularly infections caused by *Eimeria* sp.) and reported that clinico-pathological features of various species of *Eimeria* infections were much reduced if certain management practices were observed and strictly adhered to. In particular, this author emphasised proper construction of cages and pens, avoidance of overcrowding, frequent cleaning of pens and cages, and good nutrition as key steps in preventive healthcare in rabbit management systems.

Training

Training of limited-resource farmers on basic husbandry techniques has contributed to the sustainability of these production systems. Lukefahr (1999b) observed that rabbit farmers may not have access to proper training in rabbit management practices, noting that this has contributed to the failure of many past rabbit projects. Moreover, Lukefahr (2007) reported that formal farmer training, although usually taking place at an R&D training centre, may be more appropriate when held on small demonstration farms in the region. Thus, training of farmers on basic rabbit management techniques, especially in smallholder units, is seen as a priority step in sustainable rabbit R&D programmes. Several major publications (Finzi, 2000; Djago *et al.*, 2007; Lukefahr, 2010) have laid out very comprehensive training steps in rabbit management under small-scale or backyard systems. Such materials can be used as general guides for training for owners of backyard or smallholder rabbit units. The success of such training programmes can be further enhanced by a training in "needs assessment" especially for backyard rabbit systems. Lukefahr (2007) also suggested that farmers be trained whenever possible on self-sufficiency (i.e. sourcing of inputs within the farm) rather than relying on *off-farm* inputs such as imported breeding stock, commercial diets and wire for cages.

Figure 1: Traditional rabbit houses in south-western Nigeria (Courtesy: S. Oseni, IFS-supported study on smallholder rabbit farms in Nigeria).

Training of farmers could take different forms and dimensions. One form of training is coordinated within the framework of a rabbit R&D project (e.g. CECURI rabbit project, Kpodekon and Coudert, 1993). A second approach is the training organised as part of a rabbit project development by an NGO in collaboration with multiple stakeholders (e.g. HPI-CAM programme, Lukefahr and Goldman, 1985; Lukefahr *et al.*, 2000). A third approach to training is the farmer-to-farmer volunteer programme as reported from Haiti (Kaplan-Pasternak and Lukefahr, 2011), which involves local rabbit farmers spreading the knowledge of basic rabbit husbandry practices after formal training at a rabbit R&D unit. These approaches are not mutually exclusive, implying that several of these forms can be combined. In general, topics covered during training typically involve vital aspects of small-scale rabbit production, for example low investment cost, farm-based feeding, production targets, housing, breeding practices, healthcare, promotional strategies and marketing (Kaplan-Pasternak and Lukefahr, 2011).

Networking

In Africa, there is the need to create a network of stakeholders involved with sustainable small-scale rabbit project development. Networking provides an opportunity to share experiences across a large spectrum of stakeholders with a shared vision on promoting the role of backyard rabbit systems in family nutrition and welfare, gender empowerment, and poverty reduction. The goal of networking among key stakeholders (e.g. rabbit scientists/researchers, NGOs, farmer groups, and government institutions) involved in small-scale backyard systems is to build the sustainable capacity aimed at benefiting poor families. Through networking, experiences that can be scaled-up or replicated in other locations are identified. The network can also serve to identify and promote suitable R&D agendas and priorities, source funding, and facilitate multi-locational cooperation activities. Overall, a functional networking system will enable the following: (a) documenting and upscaling of good practices in backyard rabbit production systems, and (b) sharing of information on applied rabbit research, with a focus on the use of rabbit as a tool for poverty reduction, food security and the empowerment of women.

Reflections

With unprecedented and mounting levels of poverty all across Africa, accompanied by extreme cases of human suffering, the need to explore all available options to alleviate extreme poverty becomes very urgent. The potential of backyard and smallholder rabbit production systems in relation to family welfare and well-being, income generation and poverty reduction has long been recognised. It is apparent that this potential need to be explored to the fullest in order to enhance family welfare and well-being throughout Africa.

CONCLUSIONS

This paper has addressed the status of the rabbit industry and/or production in Africa with a special focus on smallholder rabbit production systems. Previous successes involving national rabbit project development and implementation activities across the continent have been highlighted, as well as major lessons learned. Such rabbit project successes need to be widely replicated across the continent so that smallholders can benefit, mostly by enhancing food security and income generation. Constraints on the development of sustainable rabbit production systems were also discussed. Critical R&D programmes were identified where prospects and opportunities for the development of sustainable smallholder rabbit production models were outlined and included the following: (a) a paradigm shift among researchers to focus on innovative *in situ* research related to the development of sustainable backyard rabbit systems; (b) a special R&D focus on the needs of smallholder rabbit farmers; (c) extension of sustainable breeding programmes to meet the requirements of smallholder rabbit farmers; (d) documentation and upscaling of good practices in smallholder rabbit units across regions; (e) development of local market value chains in smallholder rabbit development, and (f) establishment of regional and global networks of smallholder family rabbit projects. The realisation of these goals requires a new medium- and long-term sustainability research agenda with backyard rabbit farms as the primary beneficiaries. Overall, the need for a poverty focus and a pro-poor research agenda involving backyard rabbit production are emphasised.

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