23. Strengthening sustainable use of small ruminant genetic resources in the drylands in the WANA region

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Abstract

Genetic diversity in livestock is currently measured in terms of the number of breeds. Breeds have been developed within production systems, which are shaped by the natural resource base and social and economic factors. Thus, changes in the production environment will induce changes in the use of breeds. Small ruminants are a major component of the farming system and an important source of income and dietary protein in West Asia and North Africa (WANA). The WANA region is one of the main centers of domestication for sheep and goats, and is home to 75 sheep and about 32 goat breeds. These breeds are adapted to the climatic extremes of the region, from deserts to humid coastal areas. Many are highly tolerant to heat and cold stress and low quality feeds (converting unusable range resources into animal protein). However, their production levels are low when compared to exotic breeds and their products may not meet emerging consumer demands related to food quality and safety. To ensure sustainable use of livestock diversity, it is essential to improve the productivity of local breeds and the quality of their products responding to the market demands, while retaining their adaptive attributes. To achieve this goal we propose a conceptual framework with three interlinked elements: 1) Analysis of market constraints and opportunities; understanding the effect of market trends on the utilization of species and/or breeds; 2) Characterization of breeds, their production system, and the quality of their products; and 3) Designing community-based, decentralised breeding schemes where farmers are fully involved in defining breeding goals and designing and implementing selection strategies. Conditions in WANA today are similar to those predicted for other regions in the future, as a result of climate change (drier, hotter, erratic rainfall, growing water scarcity). Maintaining and developing the region's rich small ruminant diversity will, therefore, not only improve the livelihoods of millions of rural households, but also provide genetic resources that could help other regions cope with climate change.

The concept of sustainable use

There is broad agreement that sustainable use of animal genetic resources for agriculture and food production (AnGR) is the preferred strategy for maintaining livestock diversity (FAO 2007). Article 2 of the Convention on Biological Diversity (CBD) defines sustainable use as "the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations."

Many definitions of sustainability in the development literature cover three dimensions – an economic, an environmental, and a social dimension (Rischkowsky 2008). Animal genetic resources exist within production systems that are dependent on the natural resource base – changes in the environment will induce changes in AnGR. Social policies may constrain or support livestock keeping livelihoods; social attitudes affect the decisions of farmers, policy makers and consumers. Developing a concept of sustainable use requires a deeper understanding of AnGR diversity within its economic, social and ecological context. An attempt to develop such a broad concept was made by a multidisciplinary FAO expert consultation in 2006 (Weary et al. 2008).

This paper focuses on management strategies for strengthening the sustainable use of small ruminant genetic resources in the WANA (West Asia and North Africa) region using mainly research studies of ICARDA and its NARS partners as examples.

Small ruminant genetic resources in the WANA region

The WANA region known as the "Fertile Crescent" is one of the main centres of domestication for sheep and goats. ICARDA has been documenting the status and phenotypic characteristics of the sheep and goat breeds in the WANA region jointly with its NARs partners (Iñiguez 2005a, b). Many breeds are shared across the region and have important adaptive traits to dryland conditions. In WANA alone there are 75 breeds of sheep and less precisely (as it has not been well documented) 32 breeds of goats. These breeds are adapted to the semi-arid and arid conditions and climatic extremes of the region; some are thriving in fully deserted areas while others are adapted to Oasis or humid coastal regions, etc. Most of these breeds are known for their tolerance to heat and cold stress, low quality feeds (converting unusable range resources into animal protein) of degraded rangelands.

Most (about 71%) of the sheep breeds in WANA region are fat-tailed, an adaptation that allows them to cope better with fluctuation in feed availability – deposit fat during feed abundance and mobilize their fat depot during feed scarcity. Some examples of livestock adapted to constrained environments are the Barki sheep and D'man sheep, which are found in extremely dry areas of North Africa. In addition, most mountain goats are the only livestock species able to utilize range resources in rugged terrain and landscapes. Some breeds are highly demanded in the region (for example, Awassi sheep and Shami/Damascus goats). The latter is spreading more throughout the region and influencing others – demanded for crossbreeding in North Africa.

Some sheep breeds of the WANA region are threatened by indiscriminate crossbreeding (Atlas Mountain, Beni Guil, Sicilo-Sarde, Bahmei, Baluchi, Kurdi, and Cyprus fat-tailed breeds) and have suffered displacement (e.g. Beni Ashen and Karakul). Others are at risk due to high rate of inbreeding (for e.g. Chal, Moghani, Sanjabi, and Zel) or are just few in number (e.g. Güney Karaman and Gökçeada) and close to extinction (e.g. Ödemiş). Status of many of the goat breeds in the region is largely unavailable; they are threatened by indiscriminate crossbreeding (e.g. Mountain goats, Zaraibi), small population size (e.g. Dihewi, Zaraibi, Norduz, Gürcü and Abaza) or their number is declining (e.g. Angora goat) following abolishing of the government subsidies for their special product, and probably due to low market prices of Mohair and low milk yield of the breed. Other reasons for breeds at risk were absorption by nearby breed, competition with more productive breed, adoption of more profitable irrigated agriculture (in

which more attention is paid to dairy cattle), neglect of the breeds because of their low productivity, lack of market for their products, and lack of local institutions e.g. farmers' organization for processing and marketing of their produce (Iñiguez 2005a, b).

Challenges facing WANA's drylands

The recent climate change scenarios show that most of the Near East region will face a decrease in water availability of up to 40 mm per year. The number of dry days is expected to increase everywhere in the region, with the exception of some central-Saharan areas, while the number of frost days is expected to decrease. Once the temperature increases reach 3 or 4°C the length of growing seasons will decrease. Yields of the key crops across Africa and Western Asia may fall 15 to 35 percent or 5 to 20 percent, depending on whether there is weak or high carbon fertilization, respectively (FAO 2008 based on IPCC 2007).

The expected additional stresses from climate change in most of the region will increase the already existing vulnerability to climatic fluctuations in the WANA region. An analysis of the coefficient of variation of the maximum NDVI for the period 1982-2000 showed that there is ample evidence of hotspots of response and vulnerability to climatic fluctuations in the region (Celis et al. 2007). The hotspots include North Africa, from Morocco into Tunisia; the Sahel, from Mauritania into Sudan, Eritrea, northern Ethiopia and turning south into Somalia; and the Fertile Crescent, from Jordan, Syria, Iraq, turning southeast into Khuzistan province in southern Iran. These areas are already currently characterized by severe droughts, degradation of land, water and vegetation resources, and sometimes famines. They are already facing conditions as predicted from climate change (drier, hotter, erratic rainfalls, and fragile water supply, Thomas et al. 2007).

The expected impact of climate change has to be seen also in the background of other trends shaping agricultural environment in general, such as already high and growing populations, persistent reliance on income from agriculture; unstable off-farm income due to political and socioeconomic factors discouraging investment into industry and services, and dwindling water resources due to overuse and lack of policies to protect the resources or use them efficiently (Thomas, 2008).

Small ruminants (sheep and goats) represent a major component of the farming system and are an important source of income and animal protein for the rural poor in the dry areas of WANA (Iñiguez 2004). It is estimated that, assuming a flock size that fluctuates between 20 to 50 heads per family, about 4-10 million families benefit from small ruminants in NENA (Iñiguez 2005a). They require low initial investment and use marginal land and crop residues to produce milk and meat. In particular in pastoral and agro-pastoral systems where extensive grazing is the main resource to produce high-value agricultural products, animals have become an essential aspect of the cultural, social and religious life of the people who depend upon them, and specific breeds adapted to the needs of the people and the environmental stressors have been developed (Scherf et al. 2006).

The increasing demand for animal products results in increasing interactions of small scale livestock producers with markets that provide both opportunities and risks. At present small ruminant producers in the region are targeting local markets for dairy and meat products and regional markets (the Gulf region) for meat. However, the share of the WANA region in meat supply of the Gulf market is decreasing The reasons are health-related trade restrictions

for small ruminants, poor market infrastructure, and lack of information about the dynamics of export markets and lack of polices to effectively respond to export market requirements (Aw-Hassan et al. 2005). The incidence and control of zoonotic diseases have received little attention in the region which is already causing difficulties to farmers with marketing and trade. Urban consumers are becoming more demanding with regard to food quality and retailers that demand homogenous, reliable and safe supplies are increasingly entering the markets in WANA. Market structures often lack transparency that limits farmers in their attempt to capitalize market opportunities. Thus, issues of product quality and safety are turning so important that they may restrict the small holders from accessing the markets. Another important trend in the region is the decreasing contribution of rangelands to the small ruminant diets. A survey in the Syrian steppe showed that depending on the mobility of the livestock producers rangelands contributed only 22 to 36% to the sheep diets in 2004, an average rainfall year (Dutilly-Diane et al. 2006).

Strengthening sustainable use of local small ruminant breeds

The indigenous sheep and goat breeds in the WANA region are well adapted to the dry land conditions and are expected to cope better with the consequences of climate change than exotic breeds. Thus, sustaining and improving the use of the indigenous breeds, which have adapted over centuries to the dry and hot areas, is also an important coping strategy for climate change. However, the production levels are low when compared to exotic breeds and their products may not meet emerging consumer demands related to food quality and safety. To ensure sustainable use of livestock diversity, it is essential to improve the productivity of local breeds and the quality of their products responding to the market demands, while retaining their adaptive attributes.

To achieve this goal we propose a conceptual framework with interlinked elements:

- Analysis of market constraints and opportunities; understanding the effect of market trends on the utilization of species and/or breeds.
- Characterization of breeds, their production system, and the quality of their products.
- Designing community-based, decentralised breeding schemes where farmers are fully involved in defining breeding goals and designing and implementing selection strategies.
- Improving production systems.

Analysis of market opportunities:
Understanding the effect of market trends on the utilization of species and/or breeds is important for preventing their extinction. In Tunisia a shift towards a thin-tailed sheep at the expense of fat-tailed Barbarin sheep by crossing them with thin-tailed ones was noticed in recent years (Bedhiaf-Romdhani et al. 2008). The study showed that this shift was mainly dictated by butchers and not by consumers. The reason was the difficulty faced by butchers to sell the fat tail, which is estimated to constitute 15% of the carcass. Consequently, the butchers were reluctant to buy fat-tailed animals. Consumers still prefer the meat of Barbarin breed and meat from fat-tailed lambs was superior in tenderness, flavor and smell in sensory tests. However, farmers admitted that butcher's preference influenced their income because they are paying favorably for thin-tailed sheep. Such trends could relatively rapidly lead to the extinction of breeds with a geographical limited distribution.

Characterization of breeds and their production environments: An integral component in any plan for sustainable utilization is characterization of genetic

diversity, i.e. of the small ruminant breeds. This includes developing an understanding of production, functional and adaptive traits. The requirement for improved characterization is particularly great in resource-poor production systems. An improved knowledge of breed characteristics may also serve as a means to identify niche products (Wurzinger et al. 2008). Characterization needs to take into account the effects of spatial and temporal variability within the production system (Rischkowsky et al. 2004). Another factor to consider is the specific characteristics of breeds under consideration that make them unique; for example, adaptive traits such as disease and heat resistance or specific feeding behaviour. Adaptation is complex and difficult to measure. One approach to this problem is to characterize adaptation indirectly by describing the production environments in which a breed has been kept over time, and to which it has probably become adapted. Comprehensive and comparable descriptions of the production environments in which animals are kept are also vital to make meaningful evaluations of performance data and to enable comparative analysis of the performance of different breeds. To address these requirements, a recognized set of 'production environment descriptors' (PEDs) has been developed as a common framework for describing breeds' production environments (Pilling et al. in press).

Genetic improvement programs: The indigenous small ruminant breeds are largely owned by smallholders in marginal dryland areas. Improving their productivity while retaining their adaptive attributes would also contribute towards mitigating climate change. In doing so more can be produced by less number of animals through the culling of mediocre animals, which otherwise will degrade the rangeland and release greenhouse gases contributing to global warming. Genetic improvement of sheep and goat breeds in such systems is constrained by small flock size, lack of animal identification and recording. Attempt so far failed due to a prescribed approach which ignored livestock owners in the planning and implementation of the breeding schemes.

However, breeding plans can be adapted to various conditions ranging from low- to high-input systems and contribute substantially to the improvement of productivity and living conditions of resource poor farmers. For example, village breeding programmes were designed for Llama smallholder farmers in Bolivia (Wurzinger et al. 2005; Wurzinger 2005) and Friesian cattle in Uganda (Nakimbugwe 2005). A few decentralized nucleus schemes handled by smallholders or their organizations have been successfully applied to small ruminants, in particular in Argentina, Perú (Mueller et al. 2002; Mueller 2003) and Morocco (Iñiguez 2005a, b). These programs have, from inception, taken into account the farmers' decisions, ownership and participation, hence their success. ICARDA in collaboration with international partners (ILRI and BOKU) launched community-based participatory and decentralized sheep breeding scheme involving farmers in Ethiopia. This approach is considered more appropriate and successful for marginal environment and socio-economic conditions where communal resources (grazing, watering points, etc) are shared. This research project involves characterization of breeds and their production system, defining breeding goals and designing breeding schemes (including simulation studies), genetic improvement of indigenous breeds, and market constraints and opportunities for the farmers.

A breeding and marketing program that has been implemented for the Sicilo-Sarde sheep breed in Tunisia brought this local breed back from the edge of extinction. The Sicilo-Sarde is the only specialized dairy sheep adapted to dry environments of North Africa. The constitution of the Sicilo-Sarde

breed association in 2003, prompted by a visionary farmer, allowed a participatory partnership involving researchers, farmers (through their association) and development agencies that tackled the reduction of production constraints and eventually established the basis for a breeding plan. This breed is being rescued by helping it bounce back to market through effective milk marketing and an efficient genetic improvement program that helped to decrease inbreeding and increase milk productivity. The association was also able to negotiate with policy decision makers for the introduction of a new legislation benefiting dairy sheep production (Djemali et al. in press).

Improving production systems: In reality, genetic improvements and management function together, as changes in management create new opportunities for selection and vice versa. Technical improvements to nutrition, management or animal health can be essential. In the WANA region, managing the production risk caused by the variability of feed availability is the central issue of small ruminant production. The high losses because of droughts and the increasing vulnerability of agropastoral communities led many governments in the region to intervene with various forms of drought assistance, mainly subsidies. These interventions are costly to governments and use resources that could otherwise be spent for development purposes (Nefzaoui et al. 2008). The recent move into producing bio-fuel from crops and crop residues competes directly with feed resources used in livestock production and contributes to increased food and feed prices. The use of cropland for bio-energy may displace livestock and production of livestock feeds. The conversion of grazing lands to crop production may force livestock into previously unused areas leading to forest clearing for livestock grazing. For example in Brazil, sugarcane plantation for bioethanol and soybean for biodiesel on lands previously used for grazing has been noted (CGIAR position paper).

Thus, alternative feeding options become of even higher importance for livestock producers. One option is to prepare multi-nutrient feed blocks from non-conventional and cheap agro-industrial by-products. Agro-industrial by-products tested included molasses, crude olive cake, sugar beet and tomato pulp (Rihawi 2005). Although many by-products can be used, a constraint is that often their production levels do not reach significant volumes to cover the large demand. In order to replace barley in the diets, multi-nutrient feed blocks with molasses and urea were successfully tested for strategic supplementation of ewes during critical periods in the production cycle, namely early mating, late pregnancy and lactation (Rihawi et al. 2007) and for lamb fattening (Iñiguez et al. 2007). However, the delivery of these products and their access by farmers pose difficulties which require due efforts in private sector participation and policy development.

Vast rangeland areas suffer from poor soil fertility, and varying levels of degradation. As a result of overgrazing, severe cutting of trees and removal of vegetation, valuable range species are being replaced by less valuable species unpalatable to livestock. Several shrubs and drought tolerant species have been introduced or used in the WANA region. This includes widely known *Atriplex* and *Acacia* species (Larbi et al. 2008) and cactus (Alary *et al.* 2007). These plants have been found useful to rehabilitate rangelands, alone, in alley cropping, or as ingredients of feed blocks. The plantation and grazing of these shrubs is faced with the inherent difficulties associated with land that is communally owned. The inconsistencies and lack of policies in relation to communal use of ranges and resources leave the communities with little motivation to conserve rangelands, and hinders the development of efficient management strategies to conserve and

regenerate them (El Dessougi 2006). Several measures have been proposed and/or tested: reseeding, water harvesting, increasing water use efficiency, enhancing soil fertility, and policy reform on land tenure. The challenge is to implement these measures in poor dryland communities.

For dairy sheep production systems alternative management options for increasing the milk offtake or targeting higher market prices can be economically interesting. For example it is estimated that about 25% of the milk yield of a dairy Awassi ewe is produced during the first 65 days of lactation (Al Jassim et al. 1999). Early weaning through creep feeding of lambs is an interesting option to increase the milk offtake. Feeding experiments showed that, with adequate feeding, lambs can be weaned at an age of 45 days (Rihawi et al. 2008). Out-of season sheep milk production to capture higher market prices is also possible. Although representing additional costs, producing milk out-of season can bring extra benefits to farmers allowing them to recover costs and make a profit because of the better prices of milk products (ICARDA 2005). It is interesting to note that some farmers are already moving into this type of specialized production by their own initiative.

In Syria, national reports have shown that the amount of fresh milk sold has dropped, as a result of the progressive replacement of fresh sheep milk with cow milk (Iñiguez and Aw-Hassan 2004). This trend has apparently triggered an increase in the number of more intensive dairy production systems which process their own milk, particularly yogurt, rather than selling it as fresh milk at a low price. Improving quality, shelf-life and marketability of dairy products is critical for farmers to respond to the market demands of food safety and hygiene. ICARDA researchers and extension workers applied a participatory approach to improve the product quality of Syrian farmers (Hilali et al. 2006). Workshops and trainings (on milk hygiene, improved yoghurt processing and culture management) were held involving women. Low cost interventions such as the use of industrial starters in making yoghurt with improved firmness and appropriate processing methods were developed. As a result the farmers achieved higher market prices for their yoghurt and improved their competitiveness in the market.

Conclusions

Conditions in many areas in WANA today are similar to those predicted for other regions in the future as a result of climate change (drier, hotter, erratic rainfall, growing water scarcity). Maintaining and further developing the region's rich small ruminant diversity will, therefore, not only improve the livelihoods of millions of rural households, but also provide genetic resources that could help other regions cope with climate change.

To date only few small ruminant breeds are at risk in the WANA region. However, there are still large gaps in the phenotypic and genetic characterization of small ruminant breeds, in particular of goat breeds, and in the documentation of their population status. Adaptive traits of the breeds have not been studied. There is a high potential to improve the productivity of the small ruminant flocks through both genetic improvement and management interventions. The greatest challenge in the near future for sustaining the use of small ruminants will be the supply of adequate feed resources in times of rapidly increasing feed prices and low contribution of rangelands to the diets.

References

Alary, V., A. Nefzaoui and M. Ben Jemaa. 2007. Promoting the adoption of natural resource management technology in arid and semi-arid areas: Modelling the impact of spineless cactus in alley cropping in Central Tunisia. *Agricultural Systems* 94: 573–585.

Aw-Hassan, A., F. Shomo and L. Iñiguez. 2005. Helping small enterprises capture the livestock products market in West Asia and North Africa. *Caravan* 22: 14-17.

Al Jassim, R.A.M, D.I. Aziz, K. Zorah and J.L. Black. 1999. Effect of concentrate feeding on milk yield and body-weight change of Awassi ewes and growth of their lambs. *Animal Science* 69: 441-446.

Bedhiaf-Romdhani, S., M. Djemali, M. Zaklouta and L. Iñiguez. 2008. Monitoring crossbreeding trends in native Tunisian sheep breeds. *Small Ruminant Research* 74: 274-278.

Celis, D., E. De Pauw and R. Geerken. 2007. Assessment of Land Cover and Land Use in Central and West Asia and North Africa. Part 2. Hot spots of land cover and drought vulnerability. ICARDA, Aleppo, Syria.

CGIAR position paper on bio-fuel. www.sciencecouncil.cgiar.org/fileadmin/user_upload/sciencecouncil/Reports/Biofuels_for_web.pdf

Convention on Biological Diversity (CBD). Convention Text. Concluded at Rio de Janeiro, 5 June 1992. (available at http://www.biodiv.org/convention/convention.shtml).

Djemali, M., S. Bedhiaf-Romdhani, L. Iñiguez and I. Inounou. Saving threatened native breeds by autonomous production, involvement of farmers organization, research and policy makers: The case of the Sicilo-Sarde breed in Tunisia, North Africa. Livestock Science (in press)

Dutilly-Diane, C., C. Saint-Macary, J. Tiedeman, G. Arab, N. Batikha, F. Ghassali and E. Khoudary. 2006. Mobility and feeding strategies in the pastoral systems of the Syrian Badiah. *In* Les productions de l'élevage méditerranéen: défis et atouts: Proceedings 2ème séminaire du réseau méditerranéen élevage. 18-20 Mai 2006, Saragosse, Espagne.

El Dessougi, H. 2006. Restoring soil fertility in dry areas. *Caravan* 23: 23-25.

FAO. 2008. Climate Change: Implications for Agriculture in the Near East. Twenty-Ninth FAO Regional Conference for the Near East, Cairo, the Arab Republic of Egypt, 1-5 March 2008. FAO, March 2008, NERC/08/INF/5 March 2008

FAO. 2007. The State of the World's Animal Genetic Resources for Food and Agriculture, edited by B. Rischkowsky and D. Pilling. Rome. (http://www.fao.org/docrep/010/a1250e/a1250e00.htm)

Hilali, M., L. Iñiguez, and M. Zaklouta. 2006. Improving value addition: Simple technological changes in the processing of milk in Northern Syria. 57th Annual Meeting of the European Association for Animal Production (Ynze van der Honing, ed.), 17-20 September 2006, Antalya, Turkey.

ICARDA. 2005. Annual Project Report 2004. Megaproject 4: Diversification and Sustainable Improvement of Rural Livelihoods in Dry Areas. ICARDA, Aleppo, Syria.

Iñiguez, L. 2004. Goats in resource-poor systems in the dry environments of West Asia, Central Asia and the Inter-Andean valleys. *Small Ruminant Research* 51:137-144

Iñiguez, L. (Ed.). 2005a. Characterization of Small Ruminant Breeds in West Asia and North Africa. Vol. I. West Asia . ICARDA, Aleppo, Syria.

Iñiguez, L. (Ed.). 2005b. Characterization of Small Ruminant Breeds in West Asia and North Africa. Vol. II. North Africa. ICARDA, Aleppo, Syria.

Iñiguez, L. and A. Aw-Hassan. 2004. The sheep and goat dairy sectors in Mediterranean West Asia and North Africa (WANA). Pages 13-22 *in* Future of the Sheep and Goat Dairy Sectors: Proceedings of the Symposium. 28-30 October 2004, CIHEAM, Zaragoza, Spain.

Iñiguez, L., S. Rihawi, M. Wurzinger and W. Knaus. 2007. Lamb fattening for higher income. *Caravan* 24: 44-46.

IPCC, 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, eds.) Cambridge University Press, Cambridge, United Kingdom and New York, USA.

Larbi, A., A. Khatib-Salkini, P. Bolus and L. Iñiguez. Shrub yield and fodder quality

variations in a non-tropical dryland environment in West Asia. Agroforest Syst (in press).
Mueller, J.P. 2003. Estrategias para el mejoramiento genético de pequeños rumiantes. Conferencia invitada. Pages 13-14 *in* Memorias III Congreso de la Asociación Latinoamericana de Especialistas en Pequeños Rumiantes y Camélidos Sudamericanos (ALEPRYCS). 7-9 de Mayo, Viña del Mar, Chile.
Mueller, J.P, E.R. Flores and G. Gutierrez. 2002. Experiences with a large-scale goat genetic improvement project in the Peruvian highlands. Communication 25-12 i*n* Proceedings VII World Congress on Genetics Applied to Livestock Production. 19-23 August 2002 Montpellier, France.
Nakimbugwe, H. 2005. Open-nucleus dairy cattle breeding programme in the Lake Victoria crescent region of Uganda. Dissertation am Insitut für Nutztierwissenschaften, Department für Nachhaltige Agrarsysteme, Universität für Bodenkultur, 129; Wien.
Nefzaoui, A., M. El Mourid, H. Ketata and A. Sidahmed. 2008. Future trends in small ruminant production in the NENA Region. *In* Developing a Small Ruminant Research and Development Strategy for Rural Poverty Reduction in Non-Tropical Dry Areas of the Near East and North Africa. Proceedings ICARDA/IFAD Expert Consultation, 9-11 March 2008, Cairo, Egypt, published on CD.
Pilling, D., B. Rischkowsky and B. Scherf. Report of the FAO/WAAP Workshop on Production Environment Descriptors for Animal Genetic Resources held Caprarola, Italy, 6–8 May 2008. FAO, Rome (in press).
Rihawi, S. 2005. Expanding the menu: Transforming by-products into nutritious feed. *Caravan* 22: 28–30.
Rihawi, S., L. Iñiguez and B.A. Rischkowsky. 2007. Feeding Management Strategies to Reduce Risks in Milk Production of Awassi Sheep in Northern Syria. *In* First International Conference on Food Safety of Animal Products. 12-14 November 2007, Amman, Jordan.
Rihawi, S., L.Iñiguez and W.F. Knaus. 2008. Creep feeding management linked to fattening lambs with least cost diets. *In* Small ruminant production diversification and genetic diversity. Proceedings ICARDA/Boku workshop. 29 February-1 March 2008, ICARDA, Aleppo, Syria.
Rischkowsky, B. 2008. Sustainable use of animal genetic resources – what concepts are available? Pages 31-40 *in* Report of the FAO/WAAP Expert Meeting on Sustainable Utilization of Animal Genetic Resources (FAO/WAAP, ed.). FAO, Rome. Available at http://www.fao.org/ag/againfo/programmes/en/genetics/angrvent-docs.html
Rischkowsky, B., E.F. Thomson, R. Shnayien and J.M. King. 2004. Mixed farming systems in transition: the case of five villages along a rainfall gradient in north-west Syria. *Experimental Agriculture* 40(1): 109-126.
Scherf, B., B. Rischkowsky, I. Hoffmann, M. Wieczorek, A.Montironi and R. Cardellino 2006. Livestock genetic diversity in dry rangelands. *In* The Future of Drylands, International Scientific Conference, Session 1: Conservation of Biodiversity, Cultural and Natural Heritage in Drylands (UNESCO). 19-21 June 2006, Tunis, Tunisia. Available as Breed Diversity in Dry Ecosystems. Commission on Genetic Resources for Food and Agriculture, Intergovernmental Technical Working Group on Animal Genetic Resources for Food and Agriculture, 4th session, Rome, 13-15 December 2006, CGRFA/WG-AnGR-4/06/Inf. 9, 12 pp.
Thomas, R.J., E. De Pauw, M. Qadir, A. Amri, M. Pala, A. Yahyaoui, M. El-Bouhssini, M. Baum, L. Iñiguez and K. Shideed. 2007. Increasing the resilience of dryland agro-ecosystems to climate change. *Journal of Semi-Arid Tropical Agricultural Research* 4(1): 1-37.
Thomas, R.J. 2008. Opportunities to reduce the vulnerability of dryland farmers in Central and West Asia and North Africa to climate change. *Agriculture, Ecosystems and Environment* 126: 36–45
Weary, D., D. Pilling and B. Rischkowsky. 2008. Report of the FAO/WAAP Expert Meeting on Sustainable Utilization of Animal Genetic Resources held in Ferentillo, Italy, 2–4 July 2006. Pages 1-17 *in* Report of the FAO/WAAP Expert Meeting on Sustainable Utilization of Animal Genetic Resources (FAO/WAAP,

ed.). FAO, Rome. Available at http://www.fao.org/ag/againfo/programmes/en/genetics/angrvent-docs.html.

Wurzinger, M. 2005. Estimation of genetic parameters and design of a breeding programme for a llama population in the High Andes of Bolivia. Dissertation. Insitut für Nutztierwissenschaften, Department für Nachhaltige Agarsysteme, Universität für Bodenkultur, 68; Wien.

Wurzinger, M., L. Iñiguez, M. Zaklouta, M. Hilali and J. Soelkner. 2008. The Syrian Jabali goat and its production system. *Journal of Arid Environments* 72: 384–391.

Wurzinger, M., D. Ndumu, R. Baumung, A. Drucker, O. Mwai and J. Sölkner. 2005. Indigenous selection criteria in Ankole cattle and different production systems in Uganda. *In* 56th Annual Meeting of the European Association of Animal Production (EAAP), 5–8 June 2005 in Uppsala, Sweden.

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