Challenges to generate adaptable technologies and to build up strategic alliances for small ruminants research in low input systems: case of Tunisia

Rekik M., Ben Salem H., Khbou-Khamassi M.

in

Chentouf M. (ed.), López-Francos A. (ed.), Bengoumi M. (ed.), Gabiña D. (ed.). Technology creation and transfer in small ruminants: roles of research, development services and farmer associations

Zaragoza : CIHEAM / INRAM / FAO
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 108

2014
pages 211-225

Challenges to generate adaptable technologies and to build up strategic alliances for small ruminants research in low input systems: case of Tunisia

M. Rekik[1], H. Ben Salem[2] and M. Khbou-Khamassi[3]

[1]International Centre for Agricultural Research in the Dry Areas (ICARDA), P.O. Box, 950764 Amman 11195 (Jordan)
[2]Institut National de Recherche Agronomique de Tunisie, Laboratoire des Productions Animales et Fourragères, rue Hédi Karray, 2049 Ariana (Tunisia)
[3]Ecole Nationale de Médecine Vétérinaire, 2020 Sidi Thabet (Tunisia)

Abstract. In Tunisia and in most countries of the West Asia and North Africa (WANA) region, research in small ruminants is historically well embedded in the national agricultural research system. It faces challenges of generating cost-effective and transferrable technologies for the benefit of low input production systems. These systems are managed by small holders with very fragile technical and economic assets. This research inherited a biological material that is characterized by breeds and local populations with a limited potential to reproduce, to grow or to yield milk. Furthermore, future research programs need to incorporate other emerging challenges such as global warming, sustained increase of primary feed ingredients, shifts in the consumer demand for a safer quality of products and a less seasonal availability of products in the market. Researchers should also bear in mind that in a post-revolutionary context, sheep sector should contribute for a higher employability of the rural young population. Amongst WANA countries, research in small ruminants in Tunisia has a number of success stories and in some cases their transferability to the producing communities is yet hampered by unsupportive policies. Not being exhaustive, technologies related to quantitative genetic characterization of growth traits, understanding of environmental factors affecting reproductive patterns as well as integration of unconventional feed resources in diets and their interactions with products quantity, quality, reproduction and animal health are relevant beyond the Tunisian context and may be shared by WANA research teams. Future research programs need to be structured around a national coordinating body with a main mandate to accurately define research priorities and needs. Other national aims should target outscaling transfer of confirmed technologies, upgrading the research capacity of teams and labs and increasing research productivity and efficiency through integration of biotechnologies and molecular genetic tools. To achieve these objectives, research in small ruminants must rely on strategic alliances. Firstly, there should be recognition of the role of professional organizations and local communities in the process of defining research needs and priorities. Secondly, the logistic support of international institutions should continue and increase. Thirdly, there is a need to boost access of young researchers to training opportunities outside Tunisia and to facilitate exchanges with the international scientific community through a more intensive participation and attendance in meetings and congresses.

Keywords. Small Ruminants – Low input systems – Research – Technologies' Transfer – WANA Region.

Défis pour la génération de technologies appropriées et pour l'élaboration d'alliances stratégiques en matière de recherchesur les petits ruminants dans les systèmes à faibles intrants : cas de la Tunisie

Résumé. *La recherche sur les petits ruminants en Tunisie comme dans d'autres pays l'Afrique du Nord et de l'Asie de l'Ouest et de (région WANA) est bien ancrée dans le système national de recherche agronomique. Cette recherche fait face à des défis de générer des technologies transférables dans un contexte de production où les éleveurs sont des propriétaires de petits troupeaux avec une assise technique et financière très fragile. Cette recherche a hérité d'un matériel biologique composé de races et populations locales avec des potentialités très modestes quant à la reproduction, la croissance ou la production laitière. Par ailleurs, les nouvelles orientations de la recherche doivent incorporer d'autres défis émergeants comme le réchauf-*

fement climatique, l'accroissement soutenu des prix de matière première en alimentation animale, les nouvelles tendances de consommation qui optent vers des produits sains et une moindre dépendance des produits dans les marchés. La recherche ovine et caprine ne doit pas aussi négliger que dans un contexte post-révolutionnaire, le secteur doit contribuer à l'employabilité des jeunes et des femmes dans les zones rurales. Parmi les pays de la région WANA, la recherche ovine et caprine en Tunisie est riche d'un certain nombre de « success stories » dont malheureusement certaines sont restées sous forme de résultats dans les journaux scientifiques internationaux et leur transfert aux communautés d'éleveurs a été handicapé par des politiques peu favorables. Sans être exhaustif, on peut citer parmi ces technologies qui peuvent être partagées avec d'autres pays similaires de la région WANA, la caractérisation quantitative des caractères de croissance, les facteurs extrinsèques qui influencent la fonction reproductive, l'intégration dans les rations des ressources alimentaires non conventionnelles et leur impact sur la quantité et la qualité des produits, la reproduction et la santé animale. Les programmes futurs doivent être structurés autour d'une structure nationale de coordination qui doit être mandatée pour définir avec précision les priorités de la recherche. D'autres objectifs nationaux doivent être recherchés de manière à élargir les processus de transfert, à mettre à niveau les laboratoires et les équipes de recherche et à intégrer, pour plus d'efficience, les outils de biotechnologie et de génétique moléculaire. A cet effet, des alliances stratégiques doivent être établies d'abord avec la profession dont le rôle dans la définition des priorités de recherche doit être reconnu. Par ailleurs, le soutien logistique de certaines institutions internationales doit être renforcé comme celui des institutions de formation et de networking pour favoriser une meilleure participation des jeunes chercheurs.

Mots-clés. *Petits Ruminants – Systèmes à faibles intrants – Recherche – Transfert de technologies – Région WANA.*

I – Introduction

The region of the world comprised between the latitudes 35°N and 35°S includes most of the dry areas of the globe where rainfall is scarce with a very erratic pattern. It is also the region home for approximately 55% of the sheep and goats' population. This is not coincidental as livestock is the most important agricultural activity in dry areas and amongst livestock species, small ruminants are the fittest to cope with aridity. Total population of sheep, goats and camelids reaches 353 10^6 heads, 82% of which is owned by smallholders and 3.5 million families benefit from them (Iniguez, 2011). In the poor parts of the arid lands, livestock production is a key to food security and an important economic issue to alleviate poverty. In these areas, production systems face 2 antagonistic driving forces. In one hand, there is an increasing demand for small ruminant products, hence market expansion and opportunities for small-scale producers. At the same time, food security of the livestock species is threatened by water scarcity which restricts fodder production in addition to the continuous degradation of pastures as a result of overgrazing. Contribution of pastures in providing feed to flocks has declined from 75 to 25% since 1970's (Iniguez, 2011). Policies addressing the issue of livestock keeping in dry areas need to cope with 2 further global additional forces for change: (i) global warming aggravating feed shortages and worsening the health status and (ii) global, sustained rise in price of primary feed ingredients impacting negatively on the strained household economy. In Tunisia, sheep and goat production remains an important economic activity particularly in central, western and southern parts of the country. Research in this field is well embedded in the national agricultural research system and historically, it was a major component of the research program undertaken by the National Institute of Agricultural Research (INRAT) up to the 1980's. Even though, research in sheep and goats is still important at INRAT, it has now been relayed by several other agricultural and non-agricultural faculties and research institutes. This paper aims to analyze the current status of research in sheep and goats in Tunisia and brings up thoughts and ideas to make it more efficient in terms of producing technologies that will empower the farming communities in facing all sorts of challenges and reduce poverty of smallholders in low input systems.

II – Challenges facing research in small ruminants in Tunisia

1. Structural challenges

The total sheep and goat population in Tunisia is estimated around 8.3 10^6 heads (Statistics of the Ministry of Agriculture) while the pastoral area is only 5.5 10^6 ha. Sheep and goats density is one of the highest in North Africa and West Asia (WANA) exceeding 50 heads/km^2. The sheep and goats' population is composed of 4 local breeds of sheep dominated by suckling breeds while the goat population is represented by a heterogeneous population. For more details concerning the Tunisian breeds of sheep and goats, please refer to the review by Rekik *et al.* (2005). As in most other arid countries of the WANA region, local sheep and goat breeds have been little selected for improved growth or reproductive performances. As reported by Ben Hamouda (1985), local breeds have a very slow growth pattern after 30 days of age yielding light lambs at weaning. Productive outputs are limited, within other causes, by a low reproductive efficiency; mainly, a delayed onset of puberty, large anoestrus periods and low fertility and prolificacy. Reproductive events, in all the species and ecosystems, are determined by genetic and environmental cues. Animals reared, for a long time in semi-arid environments are surely the best genotypes for surviving under the harsh climatic and nutritional conditions of these areas, but genetic selection for improvement of reproductive and productive yields is scarce. Thus, the constraints of the arid environments have largely contributed to establishment of sheep and goat breeds that are reproductively less efficient than breeds of more temperate areas. Sheep and goat breeds of arid and semi-arid zones are often late-maturing animals, reaching puberty at a delayed age and starting their reproductive life later than in more favorable natural conditions. Delaying initiation of the reproductive life is also a deliberate decision of the farmers ensuring sufficient growth and development of the females prior to reproduction. Furthermore, *in utero* undernutrition, a very common event when pregnant dams are inadequately fed under arid and semi-arid conditions, contributes to a reduced reproductive fitness of the progeny. As a result of this low genetic potential and the impact of the environment, the annual female productivity in sheep and goat flocks, crosscheck of several estimates, is below 0.8 lamb or kid.

Sheep are mainly represented in the North and the Centre of the country while goats are mainly represented in the South with 56% of the animals. Irrespectively of the geographical zone, most production systems are pastoral relying on the very poor natural vegetation of the forest or the steppe while integrated crop-livestock production systems can be found in the sub-humid and the semi-arid areas. The statistics of the latest national survey of agricultural holdings (Ministry of Agriculture, 2005) estimate the number of sheep and goat producers to be around 300,000; no reliable more recent figures are available. With an average number of people per house hold between 5 and 5.5, therefore, at least 1,500,000 people benefit from small ruminant production. It is of course understood that small ruminants partially contribute to the families' income as most producers run, at the same time, other agricultural and non-agricultural activities. The population of sheep and goat owners is found in rural areas where poverty is very high (60-70%) and is composed of aged persons with a high illiteracy rate. This population, by its structure, is not very open to new technologies and is very conservative with regards the way, flocks are managed.

Over the last decades, there is a trend towards having a high concentration of sheep and goats within small flocks of less than 30 breeding females on smallholdings of less than 20 ha under a sedentary production system (Table 1). These mutations exerted profound changes on the systems' typology with the emergence of flocks interacting with cropping or relying on purchased feed. Moreover, the livestock-allowed space has substantially declined and on the reduced size of the households, there is an expansion of added-value cropping practices at the expense of fodder production. Such practices can further aggravate the threat to water scarcity and soil fertility depletion and in any case, have a negative horizon because of climate change.

Table 1. Changes in the distribution (%) of sheep in Tunisia according to the size of the farm (ha)

Size of the farm	1980[1]	1993[1]	1995[2]	2005[3]
0-20 ha	49.9	54.0	57.5	61.9
20-50 ha	22.4	19.9	20.0	19.3
> 50 ha	27.7	26.1	22.5	18.8
Total	100	100	100	100

Source: (1) World Bank, 1995, (2) Ministry of Agriculture, 1995, (3) Ministry of Agriculture, 2005.

2. Environmental challenges

The dry areas which are home to high livestock populations are facing serious challenges including poverty, drought, land degradation, water scarcity and food insecurity. These challenges are exacerbated by climate change. Therefore, the vulnerability of the production systems involving small ruminants will be increased unless appropriate adaptation strategies are developed (Ben Salem *et al*., 2011). In addition to feed scarcity and unbalanced nutrient supply, sheep and goats will be exposed to environmental stressors including heat and water stresses. The plant will also undergo the impacts of these stressors, resulting in a continuous decrease of the vegetation cover rate and the increase of the levels of secondary compounds in consumable biomass like tannins which might compromise productive and reproductive performances of these animals. Indeed, inappropriate supply of feeds and nutrients will have direct and indirect effects on digestive and metabolic patterns. These disturbances would be reinforced with the insufficient supply of drinking water to the animal resulting in decreased feed intake and digestion. Some secondary compounds which are synthesized by the stressed plant as auto defense mechanism could impact negatively on microbial proliferation and activity in the rumen.

The health issue is also of paramount importance. Since several years, we assist to the spread of animal epizooties and an increased incidence of certain diseases in regions of the world where they have never been reported before; this fact was attributed to climate change. Indeed, this increase was correlated to both alterations of vector population size and dynamics, and in another side to the increases in pathogen replication rates directly influenced by more warm temperatures during arthropod infection (Relman *et al*., 2008). Arbovirose diseases are the best example to this fact (arrow 1 in Fig. 1). The same figure shows the connections between animal production, ecosystem change that enclose climate and environmental changes and also occurrence of emerging and re-emerging animal diseases.

The history of bluetongue in the Mediterranean countries illustrates very well this situation. Since the year 2000, the epidemiological situation with regard to bluetongue disease has dramatically changed in the region and Tunisia reported for the first time outbreaks due to serotype 2. In the following years, the incidence rate is still variable and two new serotypes were identified: serotype 1 in 2006 and serotype 4 in 2009. From year 2000, a vaccination program using a modified live vaccine was implemented to protect small ruminants against the disease. Actually a vigilant state is maintained to monitor any introduction of other serotypes, especially the serotype 8 that could affect cattle (Fig. 1).

The occurrence of Rift Valley Fever in 2010 in Mauritania and in 2011 in Egypt, makes Tunisia a threatened country and multiple epidemiological surveys are conducted to search for any serological traces of the virus.

Fig. 1. Risk estimation for introduction of other bluetongue serotypes in Tunisia (Adapted from Benhassine *et al*., 2008).

The climate change has also an indirect influence on animal production (arrow 3 in Fig. 2), since it causes decreases in milk production and weight losses due to water and pasture scarcity. Indeed, the fodder reserves decrease about 30 to 50 per cent in draught periods (Amigues *et al*., 2006). The intensification of animal production to insure sufficient food supply to millions of humans is one of the multiple factors that make animals more vulnerable to diseases, although livestock sector is considered one of the most significant contributors to environmental change (arrow 2 in Fig. 2) (Steinfeld *et al*., 2006).

Fig. 2. Main relationships between emerging and re-emerging animal diseases, ecosystem change,and animal production (Adaptation from Black and Nunn, 2009).

Beside viral diseases, the parasitic ones cause a real obstacle to the development of small ruminant flocks and can cause major economic losses. Their spreading trends could be correlated to climate change. Among these diseases, four categories can be listed:

– Anemic parasitosis such as infestation by *Fasciola hepatica*: transmitted through vegetables (Akkari *et al*., 2011);

– Gastro-intestinal nematodes that is an infestation leading to high financial losses (Akkari *et al*., 2012);

– Zoonotic infection like toxoplasmosis which have both economic importance as an abortive infection and as a food-borne zoonosis (Gharbi *et al*., 2013).

– Skin parasites too could have bad consequences on small ruminants, especially mange (scabies).

3. Economic challenges

In Tunisia, small ruminants are mainly kept for meat production; in 2010, sheep and goats produced 50.5 10^3 and 10 10^3 tons of meat respectively. In comparison to 2000 figures, the increase has been much lower for sheep (7%) while it reached 25% in goats. The general demand for meat is increasing and this is best indicated by the recent trends in the sheep meat prices. The imbalance between the increased demand and the degeneration of the production potential of extensive systems will most probably lead to further increases in meat prices. As reported by Elloumi *et al*. (2011), the contribution of the sheep and goat sector to agricultural GDP is slightly below 10%. Alternation between rainy years and droughts has rendered this contribution very variable between 6.5 and 9.7% with a mean tendency of 8%. Future economic growth rates for the sheep and goat sector can be hampered by the much higher dependency on purchased feed which are mainly composed of imported ingredients. The international market index for these primary feed ingredients is continuously rising (Fig. 3) and the amount of subsidies on these items is continuously regressing. This is a consequence of the imposed adjustments of the agricultural policies by international financial institutions which relegate livestock to a less-priority agricultural activity because of its reduced competitiveness. Such adjustments are in conflict with the concept of food sovereignty in emerging countries.

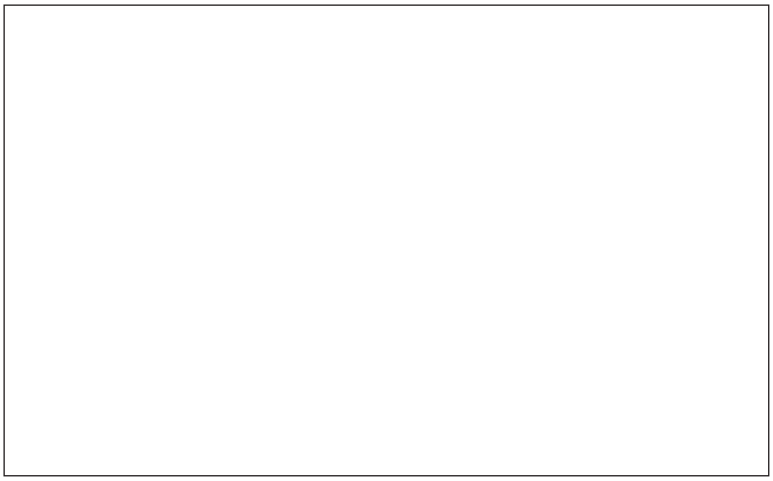

Fig. 3. Import prices of primary feed ingredients (Tunisia).

The mutation of the production systems during the last few decades mainly the pastoral and agro-pastoral ones towards a lesser contribution of rangelands to livestock feeding resulted in excessive incorporation of concentrate feeds in diets (Ben Salem, 2011). In the seventies, range vegetation represented about 80% of the diet while in the current decade it represents less than 15%. Consequently, livestock production in arid and semi-arid regions of Tunisia is depending on concentrate feeds mainly barley. However, the instability of the international market as dictated by political considerations and the impacts of frequent and extended drought seasons had resulted to raise up the prices of concentrate feeds including barley, maize and soybean meal. This situation impacts negatively on the efficiency and sustainability of these production systems. The contrasting situation is that the consumer is becoming aware of the risks of uncontrolled feeding practices on his health. Nowadays, Tunisian consumer is looking for dietetic meat and milk with less saturated fatty acids and higher in polyunsaturated fatty acids particularly conjugated linolenic acids.

In addition to food scarcity and poor management, diseases contribute to the decline of animal productivity (arrow 4, Fig. 2) hence, a decrease of farmer's income. According to Zaibet *et al*. (2009), around 40% of farmers questioned in Central Tunisia have had their animals unsold in markets because of diseases. The absence of sanitary control in small ruminant markets increases the risk for the Tunisian consumer whose is more and more vigilant and aware of food borne risks.

Multiple animal diseases handicap the economic development of small ruminant sector, we just mention two examples:

– Sheep pox disease, that is enzootic in Tunisia since several years, occurring throughout the year and causing several economic damages to breeders, because of wool and skin depreciation and weight losses. The national program to control sheep pox disease is mainly based on vaccination and vaccinated flocks are generally well protected. Nevertheless, vaccination coverage rate at a national level is still very low in some regions.

– Infectious abortive diseases like brucellosis are of great importance for public health and animal health issues. The incidence rate decreased since a vaccination program was implemented, but in certain regions where the vaccination coverage rate is low, the disease still causes a big damage to people and to animals.

The national market suffers from the illegal importation/exportation of small ruminants from Algeria and Libya, a practice which participates to disseminate animal diseases and to cause market disturbances. There is a strict animal and animal product control in Tunisia in the 25 border inspection posts (12 terrestrial, 7 aerial and 6 maritime). This control is based mainly on document and animal examinations, serology testing in some cases and quarantine according to national regulation texts. But smugglers succeed to export small ruminant and even cattle to Algerian markets, through non controlled borders. At the end of the year 2008, Tunisia reported to the OIE (World Organization for Animal Health) for the first time outbreaks of "peste des petits ruminants" (pest of small ruminants), a disease that can locally jeopardize small ruminant keeping and which was reported in Morocco for the first time early in 2008. The speed of spread of the disease could be explained by illegal movements from Morocco to Algeria and from Algeria to Tunisia. Only sanitary measures are implemented to control the disease in Tunisia.

In 2012, the extension of foot and mouth disease, serotype SAT II in the Libyan territories is highly feared in Tunisia because of the contagiousness speed of the disease among hooved animals and the illegal and uncontrolled animal movement across the borders between the two countries. The vaccination against this serotype established in Tunisia since many years most likely protected local flocks from the disease.

III – Organization of small ruminants' research and output

1. Current framework for the organization of sheep and goats' research in Tunisia

In addition to the structural, environmental and economic challenges that need to be addressed by research in sheep and goats, the organizational framework around sheep and goat research lacks crucial pathways for this research to be efficient. The main insufficiencies are listed below:

(i) Absence of strategy for the development of the small ruminants' sector at a national level. Indeed, small ruminants, unlike dairying or poultry production, do not benefit from a clear national strategy with set objectives. Very often, this sector is considered as part of the national strategy to produce red meats and is therefore confounded with other species like cattle, camels… In many instances, decisions to promote the sector of red meat do not necessarily favor sheep and goats and could be even regarded as unsupportive policies towards the sector.

(ii) Weak role of institutions or commissions that organize research in agriculture.

(iii) Lack of knowledge of the consumer behavior and demand with relation to product quality and safety.

(iv) Poor and broad definition of research priorities leading to short-term improvised research activities with low adoption rates.

(v) Research in sheep and goats is mainly carried out by agricultural and veterinarian research institutes and faculties. Funding of this research originates from ministry of agriculture, ministry of higher education and research and also through international multilateral and bilateral projects. Even though insufficient, as for other agricultural research fields, but available funding could have been more efficiently used if a national coordinating body existed and the duplication of programs avoided.

(vi) Insufficient national funding and decreasing interest from international donors (FAO, World Bank, European Union, International Fund for Agricultural Development…) who are focusing on more global spectrum of the production systems.

2. Output and some success stories

It is a not an easy task to quantitatively assess the output of the research in the field of small ruminants. Historically, as mentioned above, research in this area in Tunisia has always been a major component of research in livestock and even in agriculture as a whole. In the following text, we only tempted to asses this output by inventorying papers related to sheep and goats in Tunisia that were published between 2002 and 2012. For this purpose, we targeted 2 sources of peer-reviewed papers. The first source is represented by 5 journals edited by Elsevier, a world-leading provider of scientific, technical and medical information products and services. These journals are: Small Ruminant Research, Livestock Science, Meat Science, Animal Feed Science and Technology and Animal Reproduction Science. The second source comprised all papers that were brought by PubMed which is a repository for peer-reviewed primary research reports in the life sciences. We are aware that our approach is biased as many other peer-reviewed journals with an interest in topics related to small ruminants are not covered by the two sources we spotted. Overall, 129 different papers were inventoried. These papers were published by local research teams and in many cases, in collaboration with foreign partners especially from European countries. These papers were organized by discipline and Fig. 4 depicts such distribution.

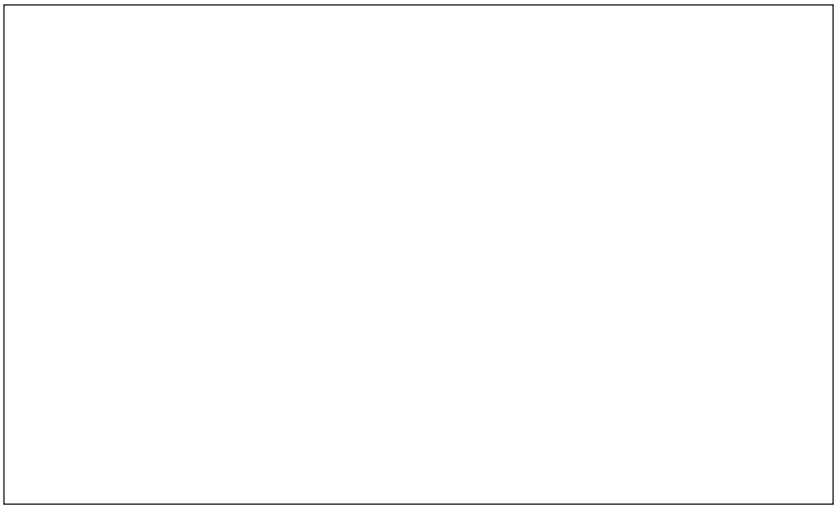

Fig. 4. % distribution of research papers/topic related to small ruminants in Tunisia between 2002 and 2012.

Some interesting features of the data in Fig. 4 are: (i) the high proportion of papers dealing with health and related topics, hence stressing the increased awareness about the health issue, (ii) under an arid environment, a great proportion of the published papers are in nutrition and we can also add that most papers deal with the use of alternative feed sources like shrubs and agro-industrial by products, (iii) papers related to physiology and the potential of adaptation are very few, even though characterization of local breeds in this area is lacking, and (iv) the inexistence of papers related to economy/system mutations although the subject is crucial for the sustainability of this sector. However, such type of papers could have been published elsewhere. As previously defined by Morand-Fehr and Lebbie (2005), the density index of sheep and goat research per year for the period 2002-2012 is 1.55.

Over the last decades, research efforts in Tunisia have yielded success stories which stand for technologies that were developed and are today transferred at a large scale. Some of these research findings are relevant to similar countries, hence contributing to enrich universal knowledge in specific fields of sheep and goats. In the area of reproduction, several studies (Khaldi, 1984; Lassoued and Khaldi, 1995; Lassoued and Rekik, 2005) have established seasonal reproductive patterns of local sheep and goat breeds and identified the modulating effect of exteroceptive factors. These findings allowed to set improved management practices of reproduction in commercial flocks and have also contributed to the development of models describing functioning and control of reproduction in Mediterranean breeds. Amongst these studies, numerous have investigated the efficiency of social cues, namely the male effect, to affect reproduction and as reported by in commercial flocks (Maatoug-Ouzini *et al*., 2013), the ram effect is today successfully used to manage clean reproduction.

In the area of quantitative genetics and amongst North African and West Asian breeds of sheep, Tunisian breeds and particularly the dominating Barbarine is one of the best genetically characterized. National data bases of flocks established in central, semi-arid Tunisia were used to study the effects of non-genetic factors on the growth performances at different ages and to estimate genetic parameters of growth traits during the first 3 months of the growth curve. The early studies were based on individual lamb performances (Ben Hamouda 1985; Khaldi *et al*. 1987; Djemali *et al*. 1994) whereas later research (Jmal 1995; Bedhiaf *et al*. 1999; Ben Gara 2000) considered lit-

ter weights as a means of approaching ewe productivity. Most studies revealed that figures for the genetic parameters of individual lamb growth traits were low particularly after 1 month of age probably as a result of the importance of the maternal influence under management practices where lambs are not early weaned. This statement is backed by the findings of Bedhiaf *et al*. (2001) using an animal model that included direct and maternal effects. The authors concluded that selection should be based on the dam-offspring way. In another study, Bedhiaf-Romdhani and Djemali (2006) calculated an additive genetic ratio (a2) and a genetic maternal ratio (m2) and demonstrated that these two ratios better describe the contribution of the additive and maternal effects to the available genetic variability compared to classical heritability estimates because they remain unaffected by the residual error variance even under low-input production systems. Ben Hamouda *et al*. (2002) showed that the use of a BLUP multi-trait animal model without information on the sire genealogy reduces by only 10% to 15% the precision of the classification of lamb candidates to selection in comparison to the use of full pedigree. These findings represent a promising area for research to overcome the absence of paternal genealogy records in the selection base of the current genetic program for the suckling breeds. In a recent paper, Ben Hamouda and Rekik (2012) adjusted a non-linear function to growth of the lambs during the first 3 months using weight at birth and 3 or even 2 sequential weights. Moreover, an estimated birth weight can be used without affecting precision. This means that the classic growth performance recording protocol based on 5 weights can now be simplified to only 2 weights/lamb; the first within the first 46 days following the start of the lambing season and a second weight, 40 days later. This simplified protocol has already been adopted by Office de l'Elevage et des Pâturages (Bureau of Livestock and Pastures: in charge of animal performance recording) for a testing phase before its full adoption.

The decreasing contribution of range vegetation in livestock feeding and the increasing cost of livestock production due to the use of concentrate feeds justify the development of sustainable strategies targeting better use and integration of local feed resources in feeding calendars. There is a wealth of information on the response of sheep and goats to a wide range of fodder shrubs, cactus, and agro industrial by-products (AGIPPs) under Tunisian conditions. In a review paper, Ben Salem and Nefzaoui (2003) reported numerous formula of feed blocks composed of different AGIBPs (eg. olive cake and tomato pulp) and reported data on the response of small ruminants to diets containing these feed blocks as catalytic supplements. Some years later, Ben Salem *et al*. (2008) updated the knowledge on the replacement value of feed blocks for common concentrate feeds and compiled data generated from Tunisian and foreign laboratories on the effect of these alternative supplements on intake, diet digestibility and growth performances of sheep and goats fed on low quality forages. Livestock response to fodder shrubs and cactus was also discussed in the later paper. Overall, benefits from feed blocks include the replacement of part or the whole amount of concentrate feeds in the diet of sheep and goats without any negative impact on their growth rates. An array of diets containing fodder shrubs mainly *Acacia cyanophylla* and or *Atriplex nummularia* foliage supplemented with barley or spineless cactus is reported in the review paper by Ben Salem and Smith (2008). Some conclusions could be depicted from the later paper and refer mainly to the complementary roles between Atriplex (N source) and cactus (energy and water source) and their possible use to replace totally soya bean meal and barley, respectively. Acacia, atriplex and cactus have been successfully fed as mixed diets to sheep without any detrimental effects of tannins in Acacia and oxalates in both Atriplex and cactus. Ben Salem *et al*. (2005) showed that the inclusion of small amount of Acacia foliage (i.e. 100 g) in the diet increased the growth rate of Barbarine lamb as a consequence of an *in situ* protection of dietary proteins with Acacia tannins. In addition to tannins, saponines which are available in fenugreek seeds and some other local feed resources had also positive effects on the growth performance of Barbarine lambs and milk production in Sicilo-Sarde ewes. The defaunation activity of saponines coupled with the increased absorption rate of nutrients induced by these secondary compounds could explain the improvement of productive performances of sheep. The replacement of common feeds

with local feed resources as either fodder shrubs or AGIBPs did not deteriorate meat and milk quality. Abidi *et al*. (2010) concluded that total replacement of barley with the cladodes of spineless cactus in the diet of lambs and kids did not affect meat quality. Nasri *et al*. (2012) concluded that the administration of saponins in the diet of Barbarine lambs did extended meat stability without producing detrimental effects on meat volatile compounds. Essential oils are increasingly used to manipulate the rumen and also to improve product quality. In a recent study performed at INRA-Tunisia, it was shown that the supplementation of *Rosmarinus officinalis* or *Artemisia herba alba* essential oils did not produce detrimental effects on lamb meat volatile compounds profile and the supplementation of *Artemisia* can improve meat healthy properties (Vasta *et al*., 2013).

We can't be exhaustive, but animal research in animal health in Tunisia, even though rich and having contributed to set field strategies in fighting diseases, is still conducted in an isolated manner in the different institutions without much coordination. In many situations, it relies on foreign project availability and funding. The European counterparts are more interested in contagious diseases because of the common threat they represent. Nevertheless, parasitic and other enzootic diseases that contribute to major economic losses are very often not considered by foreign donors. Most publications with relation to animal health, refer to parasitic diseases in relation to the following agents: *Haemonchus*, *Hyalomma*, *Toxoplasma* and *Theileria*. The contribution of the veterinary research institute during past decades was mainly related to infectious small ruminant abortions like Chlamydiosis, Q fever and border disease pathologies. The studies also aimed at the genetic and molecular characterization of their agents. During recent years, the interest shifted to vector-born disease such as bluetongue disease and study of the vector *Culicoides*. For research dedicated to small ruminant health, the output should generate data which would serve the veterinary services in their effort to fight more efficiently against these diseases. The participatory approach should then be integrated in research, since farmers are the first beneficiaries.

IV – Strategic alliances towards a more efficient research

1. Searched objectives through strategic alliances

In general, adoption of new livestock technologies has been slow in dry areas, and the impact of research on small ruminant production has been less visible than in other areas of agricultural production; in high-risk environment, farmers are probably reluctant to change their practices (Iniguez, 2011). For research in small ruminants to be more efficient in sustaining the national effort in Tunisia to promote the sheep and goat sector and to assist the farmers in low input systems to be more productive and competitive, a number of strategic alliances need to be built between the main stakeholders. The main searched objectives through these alliances can be: (i) defining with accuracy research priorities; (ii) outscaling and sustainable transfer of confirmed technologies; (iii) upgrading capacity building of research teams and laboratories; and (iv) increasing research productivity and efficiency by integrating biotechnologies and molecular genetic tools. As far as research in small ruminant health is concerned, development of new technologies should be directed to:

- Multiplication of epidemiological investigations about major economic diseases and assessment of their impact on farmers' income.
- Use of spatial and geographical tools to describe animal diseases' distribution or occurrence risk.
- Development of new more efficient vaccines that allow differentiating infected from vaccinated animals (DIVA).
- Integration of genomics and bioinformatics to animal health researches which would provide some key opportunities, such as the rapid detection of emerging or re-emerging diseases.

These specific objectives must take into account larger issues with relation to natural resources preservation, water management, conservation agriculture, preservation of biodiversity and promotion of employability in rural areas. In the long-term and considering the emerging forces for change that were described earlier, research activities backed by R&D projects should develop drought mitigation strategies (long term), empower pastoral and farming communities, be multidisciplinary, enhance local know-how and focus on system resilience. Next sections will describe some of these alliances while considering the specific context of sheep and goat research in Tunisia.

2. Central role of professional institutions

We have already pinpointed the ill-definition of the research priorities in the field of small research and one of the major reasons is the disengagement of the professional institutions throughout this process. Very often, researchers and also the administration authority blame the absence, fragility and passive role of professional organizations with regards promotion of breeds and their products, sanitary defense and selection… This leads to individualization of objectives and scattered efforts which are insufficient to cope with the challenges facing production in arid environments. Although it is not within the scope of this paper, but we need to mention that the absence of professional organizations is in large part due to existing laws which limit governance modalities within these organizations. Therefore and in a general step to rehabilitate the role of the farming organizations, a revision of the legal framework addressing creation of professional association towards more efficient governance and a greater economic competitiveness is required.

The top-down way of planning and undertaking research programs has proved its uselessness and its inefficiency and is sanctioned by low transfer and adoption rates. Professional organizations in its largest significance (breeds' associations, cooperatives, farming communities) should have a decisive role in defining research needs and priorities. The administrative authority (different structures of the Ministry of Agriculture involved in research as well as research institutes and teams) must recognize the role and the indigenous knowledge of the professional organizations throughout the process of defining the research needs and priorities. This is the responsibility of the Institution of Agricultural Research and Higher Education (IRESA, Ministry of Agriculture) who has to implement sustainable ways whereby the producers' concerns and demands are prioritized as research programs and funding. Moreover, several large projects for agricultural development are carried out in the provinces of Tunisia and benefit from important financing from World Bank, African Bank of Development, International Fund for Agricultural Development, French Agency for Development…These projects should represent one of the main frames for the involvement of the professional organizations in R&D projects to reinforce technology adaptation/adoption. Very few successful experiences happened in the North West of Tunisia but unfortunately, continuity of funding ceased after short (2-3 years) agreements between research institutes and regional administrations in charge of agricultural developments.

3. Other partnerships

These other alliances refer to collaboration with international institutions that have supported research in the field of small ruminants and further support is demanded in the future to upscale the quality of research and its output. Some specific cases are raised in the following.

The activity of characterization of animal genetic resources and conservation of biodiversity is an international initiative that FAO monitors in the 5 continents. The state of progress is very variable between continents and countries. As far as small ruminants are concerned, Tunisia has marked a delay with comparison to neighboring countries and has not benefitted from the funding opportunities that were available during the last decade. The characterization process is multiple: phenotypic, genetic and at the molecular level particularly for genes affecting productivity.

However, the FAO new policies also address characterization of the products and of production systems. The National Agricultural Research System must tackle the difficulties that hamper collaboration with FAO in this field; it is an urgent matter to designate a national focal point with a mandate to federate all working specialists in this field and to take advantage of all funding opportunities that FAO is launching for countries in the WANA region.

The interaction between national research institutes and international organizations in different ways impacted positively on research programs targeting the promotion of livestock sector in Tunisia. The enhancement of capacity building by CIHEAM (International Centre for Advanced Mediterranean Agronomic Studies) and ICARDA (International Center for Agricultural Research in the Dry Areas), for example, through supporting training and facilitating participation of young researchers to scientific meetings resulted in the improvement of the quality and efficiency of research activities undertaken by these scientists. The commitment of IAEA (International Atomic Energy Agency) in funding selected technical cooperation projects (TCPs) provided important logistic support of research laboratories enabling scientists to perform advanced analytical techniques in their labs. After many decades, scientists, technicians and policy makers are convinced that "doing research and development for farmers" proved a useless way to improve agriculture sector in Tunisia but should rather be replaced by the concept of "doing research and development work with farmers". The later concept refers actually to the participatory approach in which all stakeholders including farmers work together to develop, execute and monitor research and development projects. The expertise of ICARDA in community based approach had been valorized by national research institutes (eg. INRAT) through R&D projects settled in vulnerable agro ecologies zones in Tunisia (eg. Sidi Bouzid and Tataouine regions). Among the lessons learned from such approach, the farmers should be "told" by extension what the solution is but given a basket of options. "On-size" fits all solutions do not work in practice. Farmers should be involved in all steps starting from the agro-ecological characterization of the area where they are living, the identification of constraints and opportunities of their production systems and solutions that could improve these systems to the elaboration of the community development plan (CDP) and the execution and monitoring of all activities reported in the CDP. The Mashreq and Maghreb Project coordinated by ICARDA is considered a success story among involved countries mainly Tunisia.

There are also several international organizations that could support Tunisian institutions in small ruminant health research:

– The OIE is a key partner in animal health research. In his last published editorial (June 2013), the president Bernard Vallat treated about the new technologies and their role in improving our microbial knowledge and in enhancing our anticipating approach to control and overcome animal diseases. The OIE is conducting a survey about the need of member countries and particularly the veterinary services in terms of these new technologies in order to integrate and include in scientific standards. Another kind of support, the OIE is providing: the laboratories twinning. The aim of this concept is to establish expertise for the main major animal diseases in order to improve global detection capacity, prevention and control. The OIE wishes that every member country has access to high quality diagnostic testing and technical knowledge and acquire autonomy.

– The International Livestock Research Institute (ILRI) is working to improve food security and reduce poverty in developing countries through research for better and more sustainable use of livestock. A successful partnership with the Tunisian veterinary institute in 2005-2006 yielded an original and outstanding report on access of small ruminant producers to local markets and the difficulties (sanitary, economic, social) that contributed to reduce profitability (Zaibet *et al*., 2009). Means to maintain and support partnership with ILRI should be further sought.

References

Abidi, S., Ben Salem, H., Vasta, V. and Priolo, A., 2009. Spineless cactus (*Opuntia ficus indica* f. *inermis*) cladodes in the diet of lambs and kids: Digestion, growth and intramuscular fatty acid composition. In: *Small Ruminal Research* 87, pp. 9-16.

Akkari H., Gharbi M. and Darghouth M.A., 2011. Infestation of tracer lambs by *Fasciolahepatica* in Tunisia: determining periods for strategic anthelmintic treatments. In: *Rev. Sci. Tech*., 30(3), pp. 917-29.

Akkari H., Gharbi M. and Darghouth M.A., 2012. Dynamics of infestation of tracers lambs by gastrointestinal helminths under a traditional management system in the North of Tunisia. In: *Parasite*, 19(4), pp. 407-15.

Amigues J.P., Debaeke P., Itier B., Lemaire G., Seguin B., Tardieu F. and Thomas A., 2006. *Sécheresse et agriculture. Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau*. Expertise scientifique collective, synthèse du rapport, INRA (France), p. 72. [on line: http://agriculture.gouv.fr/IMG/pdf/secheresse_agriculture_synthese.pdf).

Bedhiaf S., Ben Gara A., Ben Hamouda M., Aloulou R. and Rekik B., 1999. Estimation des paramètres génétiques des ovins de race Barbarine sous un modèle animal. In : *Proceedings of the 50th annual Meeting of the European Association of Animal Production*, Switzerland.

Bedhiaf S., Bouix J., Clement V., Bibé B. and François D., 2001. Importance du choix du modèle d'analyse dans l'estimation des paramètres génétiques des ovins à viande en Tunisie. In: *Annales de l'Institut National de la Recherche Agronomique de Tunisie*, 74, pp. 219-237.

Bedhiaf-Romdhani S. and Djemali M., 2006. New genetic parameters to exploit genetic variability in low input production systems. In: *Small Rumin. Res*., 99, pp. 119-123.

Ben Gara A., 2000. Définition des objectifs de la sélection des ovins de race Barbarine en Tunisie. In: *Options Méditerranéennes,* Series A, 43, pp. 129-136.

Ben Hamouda M. and Rekik M., 2012. Contrôle de croissance des ovins allaitants en Tunisie. II. Perte de précision sur le calcul des performances à âge type selon un protocole simplifié alternatif au protocole officiel. In: *Revue d'Elevage et de Médecine Vétérinaire des les Pays Tropicaux*., 65 (1-2), pp. 41-47.

Ben Hamouda M., 1985. Description biométrique et amélioration génétique de la croissance pondérale des ovins de race Barbarine. In :Thèse de Doctorat en Sciences Agronomiques, Université de l'Etat à Gand, Belgique.

Ben Hamouda M., Ben Gara A., Aloulou R., Bedhiaf S. and Rekik B., 2002. Le BLUP-Modèle Animal multicaractères outil de sélection massale des ovins à viande en Tunisie. In : *Book of Abstracts of the 53rd Annual Meeting of the European Association for Animal Production,* Cairo, Egypt, 1-4 September, p. 27.

Benhassine T., BenHammouda W. and El Ghoul H., 2008. Bluetongue, situation épidémiologique en Tunisie. Second regional coordination meeting on bluetongue. Spain 23-25 April 2008.

Ben Salem H., 2011. Mutations des systèmes alimentaires dans les zones arides en Tunisie et place des ressources alternatives. In: *Options Méditerranéennes*, Series A, 97, pp. 29-40.

Ben Salem H. and Nefzaoui A., 2003. Feed blocks as alternative supplements for sheep and goats. A review. In: *Small Rumin. Res.* 49(3), pp. 266-279.

Ben Salem H., Makkar, H.P.S., Nefzaoui, A., Hassayoun, L. and Abidi, S., 2005. Benefit from the association of small amounts of tannin-rich shrub foliage (*Acacia cyanophylla* Lindl.) with soya bean meal given as supplements to Barbarine sheep fed on oaten hay. *Anim. Feed Sci. Technol.* 122, pp. 173-186.

Ben Salem, H. and Smith, T., 2008. Feeding strategies to increase small ruminant production in dry environments. *Small Rumin. Res.* 77, pp. 174-194.

Ben Salem H., Rekik M., Lassoued N. and Darghouth M.A., 2011. Global warming and livestock in dry areas: expected impacts, adaptation and mitigation. In: Houshan Kheradmand (ed.) *Climate change – Socioeconomic Effects*, ISBN 979-953-307-277-6, 26 p.

Black P. and Nunn M., 2009. Impact of climate change and environmental changes on emerging and reemerging animal disease and animal production. In: 77th General Session (International Committee of the World Organisation for Animal Health), Paris, 24-29 may, pp. 1-13.

Djemali M., Aloulou R. and Ben Sassi M., 1994. Adjustment factors and genetic and phenotypic parameters for growth traits of Barbarine lambs in Tunisia. In: *Small Rumin. Res*., 13, pp. 41-47.

Elloumi M., Selmi S. and Zaibet L., 2011. Importance économique et mutations des systèmes de production des ovins en Tunisie. In: *Options Méditerranéennes*, Series A, 97, pp. 11-21.

Gharbi M., Zribi L., Jedidi M., Chakkhari H., Hamdi S., R'hayem S., Zribi N., Souli M. and Darghouth M.A., 2013. Prevalence of *Toxoplasma gondii* infection in Tunisian sheep. In: *Bull Soc. Pathol. Exot*., *in press*.

Iniguez l., 2011. The challenge of research and development of small ruminant production in dry areas. In: *Small Rumin. Res.*, 98, pp. 12-20.

Jmal S., 1995. Paramètres génétiques des caractères de la productivité de la brebis Barbarine dans le semi-aride tunisien. In : Mémoire de fin d'études de cycle de spécialisation de l'Institut National Agronomique de Tunisie, Tunisie, p. 84.

Khaldi G., 1984. Variations saisonnières de l'activité ovarienne, du comportement d'oestrus et de la durée de l'anoestrus post-partum des femelles ovines de race Barbarine : influence du niveau alimentaire et de la présence du mâle. In : Thèse de Doctorat d'Etat. Université des Sciences et Techniques du Languedoc, Académie de Montpellier, p. 170.

Khaldi G., Boichard D. and Tchamitchian L., 1987. Etude des facteurs de variation des paramètres de croissance des agneaux de race Barbarine. In : *Annales de l'Institut National de Recherche Agronomique de Tunisie*, 60 (5).

Lassoued N. and Rekik M., 2005. Variations saisonnières de l'œstrus et de l'ovulation chez la chèvre locale Maure en Tunisie. In : *Revue de l'Elevage et de Médecine Vétérinaire des Pays Tropicaux,* 58 (1-2), pp. 69-73.

Lassoued N. and Khaldi G., 1995. Variation saisonnière de l'activité sexuelle des brebis de race Queue Fine de l'Ouest et Noire de Thibar. In : *Cahiers Options Méditerranéennes*, vol. 6, pp. 27-34.

Maatoug-Ouzini S., Khaldi G., François D. and Bodin, L., 2013. Female response to ram effect in the Barbarine breed: Phenotypic and genetic parameter estimation. In: *Small Rumin. Res.*, 113, pp. 376-382.

Ministry of Agriculture, 1995. National Survey of Agricultural Holdings (Enquête sur les structures des exploitations agricoles en Tunisie). Direction Générale de la Planification, du Développement et des Investissements Agricoles.

Ministry of Agriculture, 2005. National Survey of Agricultural Holdings (Enquête sur les structures des exploitations agricoles en Tunisie). Direction Générale de la Planification, du Développement et des Investissements Agricoles.

Morand-Fehr P. and Lebbie S.H.B., 2004. Proposals for improving the research efficiency in goats. In: *Small Rumin. Res.*, 51, pp. 145-153.

Nasri S., Luciano G., Vasta V., Aouadi D., Priolo A., Makkar H.P.S. and Ben Salem H., 2012. Effect of *Quillaja saponaria* dietary administration on colour, oxidative stability and volatile profile of muscle *longissimus dorsi* of Barbarine lamb. In: *Meat Sci.* 92, pp. 582-586.

Rekik M., Aloulou R. and Ben Hamouda M., 2005. Small ruminant breeds of Tunisia. In: Iniguez, L. (Eds), *Characterisation of Small Ruminant Breeds in West Asia and North Africa*, Vol. 2. North Africa, International Centre for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria, pp. 91-140.

Relman D.A., Hamburg M.A., Choffnes E.R. and Mack A., 2008. Forum on Microbial Threats of the Institute of Medicine. In: *Global Climate Change and Extreme Weather Events: Understanding the Contributions to Infectious Disease Emergence*: Available at http://www.nap.edu/catalog/12435.html (accessed on june 2013).

Steinfeld H., Gerber P., Wassenaar T., Castel V., Rosales M. and de Haan C., 2006. *Livestock's long shadow: environmental issues and options.* In: Food and Agriculture Organization of the United Nations, Rome, p. 26.

Vallat B., 2013. New technologies offer new diagnostic and therapeutic tools for disease control. Editorial of the OIE president, available on http://www.oie.int/en/for-the-media/editorials/detail/article/new-technologies-offer-new-diagnostic-and-therapeutic-tools-for-disease-control/ (accessed june 2013).

Vasta V., Aouadi D., Brogna D.M., Scerra M., Luciano G., Priolo A. and Ben Salem H., 2013. Effect of the dietary supplementation of essential oils from rosemary and artemisia on muscle fatty acids and volatile compound profiles in Barbarine lambs. In: *Meat Sci.* 95, pp. 235-241.

World Bank, 1995. Stratégie pour le développement des parcours en zones arides et semi-arides. In : Annexes III. Rapport technique : Tunisie, Département Maghreb et Iran, Bureau Régional Moyen Orient et Afrique du Nord.

Zaibet L., Abdelhafid. H., Jabbar M. and Hammami S., 2009. Efficience du marché des petits ruminants : Rôle de la santé animale et coûts de transaction. In: *Durabilité des systèmes d'élevage des petits ruminants en Tunisie: Une approche de santé animale et marketing*. (Eds : Zaibet L., Hammami S. and Jabbar M.). Discussion Paper No. 17. ILRI (International Livestock Research Institute), Nairobi, Kenya. pp. 41-58. [http://books.google.tn/books/p/international_livestock_research_institute?id=w-fG7wE6RqsC&pg=PA41&dq=durabilit%C3%A9+des+syst%C3%A8mes+d%27%C3%A9levage&cd=4&redir_esc=y].