The contribution of ARIMNet to address livestock systems resilience in the Mediterranean region

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Addressing the challenges of agro-pastoral farming systems to strengthen their resilience

Edited by:
C. Ligda, G. Hadjipavlou




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Addressing the challenges of agro-pastoral farming systems to strengthen their resilience

Editors: C. Ligda, G. Hadjipavlou

Proceedings of the on-line Symposium "Addressing the challenges of agro-pastoral farming systems to strengthen their resilience", organised the 3rd December 2020 by the Mediterranean Working Group and the Livestock Farming Systems Study Commission in the framework of the 71st Annual Meeting of the European Federation of Animal Science (EAAP). And selected outcomes from ARIMNet and ARIMNet 2 calls projects (supported by the EU FP7 Research and Innovation Programme) tackling with resilience of livestock farming systems.

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Foreword

Diversity can reinforce the sustainability of livestock farming systems in the context of environmental, social and economic changes. When using the term “diversity”, we refer to a wide diversity of resources such as animal/breed, natural, technical, social, economic and diversity in farming practices.

The European Federation for Animal Science (EAAP) Mediterranean Working Group (WG), which deals with scientific and development issues related to animal production in the Mediterranean basin, organized a full-day Symposium within the 71st Annual Meeting of the European Federation of Animal Science (EAAP, 1-4 December 2020), in cooperation with the Livestock Farming Systems (LFS) Study Commission. The Mediterranean Agronomic Institute of Zaragoza (CIHEAM Zaragoza) collaborated with the organisers of the Symposium and is sponsoring the publication of this volume in the framework of its longstanding cooperation with the EAAP and the Mediterranean Working Group.

The Symposium, under the title: "Addressing the challenges of agro-pastoral farming systems to strengthen their resilience", focused on the challenges and drivers of change that the livestock sector faces in the Mediterranean and less-favoured areas. It included two Scientific Sessions. Session 37 (in cooperation with LFS): Combining the diversity of resources and farming practices to ensure resilience at different scales; and Session 47 (in cooperation with EAAP WG for Animal Genetic Resources): Diversity of animal genetic resources for resilient farming systems. Various drivers of change at different scales were addressed in this Symposium.

A selection of papers derived from the presentations of the Symposium is included in the current issue of Options Méditerranéennes, which aims to show the diversity of research carried out in the Mediterranean region on these topics. This volume also includes articles on the outcomes of selected projects of the ARIMNET and ARIMNET2 Calls that addressed the resilience of livestock farming systems. Three introductory articles present the context and the contents of the three parts of this publication (Sessions 37, 47 and the ARIMNET projects).

We expect this initiative to contribute towards understanding the diversity of research work in the Mediterranean region on this topic, the advances in knowledge and their impact on the resilience of farming systems. Furthermore, we hope that such work can further contribute to the scientific cooperation within the region, as bringing together the work from different research teams will provide the basis for better understanding and future common projects.

The EAAP Mediterranean WG would like to thank all the authors for their commitment and contributions to this issue, the reviewers that have participated in this process, all presenters of the EAAP Session that have participated and produced the basic material, and the Chairs of the Sessions. We would also like to thank EAAP for providing the frame for communication and exchange within the scientific society, ARIMNET and ARIMNET2 for offering the opportunity for research cooperation within the Mediterranean region.

During the editing process of these Proceedings, we received the sad news that Dr Andreas P. Mavrogenis had passed away. Dr Mavrogenis was an active member of the Mediterranean WG and FAO-CIHEAM network for many decades, making a significant contribution not only to livestock production and research in Cyprus, but in the Mediterranean region as a whole. Therefore, we would like to honour his memory by including a short obituary in this publication.

Christina Ligda, Chair of the EAAP Mediterranean Working Group

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Combining the diversity of resources and farming practices to ensure resilience at different scales

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Abstract. The resilience of livestock systems is confronted with many changes in the environment, the socio-technical and socio-economic systems. The diversity of resources mobilized by stakeholders is a source of resilience for livestock systems. On the one hand, to strengthen their resilience, they activate internal transformation levers. But on the other hand, they are confronted with the reality of the transformations allowed by the socio-technical systems in which they are embedded. This article describes the different elements and conclusions presented in session 37 of the Annual Conference of the European Federation of Animal Science (EAAP) which took place on a virtual platform in December 2020. This work shows how multidisciplinary research and research mobilizing socio-technical, economic and even social science approaches can enrich past work on livestock systems and how they are essential for building responses adapted to the diversity of territories in order to accompany the transition of livestock farming and its resilience.

Keywords. Livestock Farming System – Sociotechnical System – Resources – Diversity – EAAP2020 – Resilience.

Conjuguer la diversité des ressources et des pratiques agricoles pour assurer la résilience à différentes échelles

Résumé*. La résilience des élevages est confrontée à de nombreux changement de l'environnement, du système sociotechnique et socioéconomique. La diversité des ressources mobilisées par les acteurs est une source de résilience pour les systèmes d'élevage. D'une part pour renforcer leur résilience ils activent des leviers internes de transformation. Mais d'autre part, ils se trouvent confrontés à la réalité des transformations permises par les systèmes sociotechniques dans lesquels ils s'insèrent. Cet article décrit les différents éléments et conclusions présentés dans la session 37 de la Conférence Annuelle de la Fédération Européenne de Zootechnie (EAAP) qui s'est déroulée sur une plateforme virtuelle en décembre 2020. Ces travaux montrent comment les travaux de recherches pluridisciplinaires et ceux mobilisant des approches sociotechniques, économiques et même de sciences sociales permettent d'enrichir les travaux passés sur les systèmes d'élevage et comment ils sont indispensables à la construction de réponse adapté à la diversité des territoires afin d'accompagner la transition de l'élevage et sa résilience.*

Mots-clés. *Système d'Élevage – System Sociotechnique – Ressources – Diversité – EAAP2020 – Résilience.*

I – Introduction

The One-day Workshop "Addressing the challenges of agro-pastoral farming systems to strengthen their resilience" held during the 71st EAAP Virtual Congress in 2020 addressed the drivers of change facing the livestock sector in the Mediterranean regions and, more generally, in less-favored areas.

A variety of change factors can be considered, such as socio-technical, socio-economic and also environmental changes. These changes are driving the transition of agriculture (Geels, 2004; Geels and Kemps, 2007). A wide range of scales was addressed in this symposium, not only by looking at genetic resources but also by considering other types of resources. The diversity of these levers

can strengthen the sustainability of livestock systems in the face of climatic, social and economic changes. This concerns a wide range of resources (natural, technical, social and economic), including agricultural practices. In the context of agroecological transition, as emphasized by Thénard *et al.* (2021), the sustainable development of territories requires optimization and distribution in the use of material, immaterial and financial resources.

This article provides an overview of the contributions presented at the first session of this workshop (Session 37 of EAAP congress) on how to combine the diversity of resources to improve the resilience of farms and food systems. In addition, the integration of diversity at different scales was proposed as a central theme of this session. The first part of this article presents some research based on internal farm levers. The second part explains the role of sociotechnical level in the territorial anchoring as a driver of the agroecological transition.

II – Activating internal levers to reinforce farm resilience

An original talk introduced the session by Carvalho *et al*. (2022) who has focused on the importance of livestock integration to improve resilience of crop systems. Today, the damage to agriculture is numerous, and it is, according to the authors, the decoupling of livestock and crops that is mainly responsible for this, due to the lack of diversity in intensive systems. Therefore, integrated crop-livestock systems (ICLS) are gaining interest in many countries, because they are more diversified than specialized systems, and because they are a rare example of reconciliation between system intensification and environmental quality. However, the authors discuss other benefits of these systems and their advantages in a context of increasing uncertainty. More specifically, they focus on the resilience enhancement in ICLS that specialized systems face to economic and climatic variability. Using data from long-term experiments in southern Brazil, the authors show that ICLS increase overall system performance (e.g., in terms of human-digestible protein), increase profitability, and reduce negative environmental impacts (e.g., through soil and nutrient cycling indicators). The introduction of grazing (a new trophic level) into specialized cropping systems improves the resilience of nutrient cycling functions and of economic indicators to climatic and market stressors, and promotes the long-term stability of the whole system.

The viability of livestock farms, mainly in disadvantaged areas such as mountainous areas, is strongly linked to the sustainability of grazing management. Raniolo *et al*. (2020) suggest the need for a balance between milk production and supporting ecosystem services in highland pastures. Based on four different alpine pastures in the eastern Italian Alps, this study aimed to characterise the relationships between grazing animals, terrain morphology and the microbial community related to the nitrogen cycle. By combining the macro scale of the mountain pastures (livestock movements) and the micro scale of the soil and plots (nitrification genes) the authors showed that slope was the most important morphological variable at both spatial scales, determining animal movement patterns, and soil nitrification potential, which increased at lower slopes. Such knowledge about how grazing patterns and environmental conditions determine individual productivity and soil-supporting ecosystem services can be used to develop good practices for the sustainable management of mountain livestock-grazing systems, thereby increasing the resilience of grazing agro-ecosystems while maintaining the productivity of local livestock systems.

The inclusion of animals in the system of cultures is thus shown but who says animals call for the question of animal diversity (species and breeds). Animal diversity is one of important levers used by farmers to improve the resilience of farming systems. Joly *et al*. (2020a) showed how traditional pastoral societies use this diversity as portfolios of livestock species. For instance, in a Mongolian case-study combine slow growing resistant species, such as camels, and less resistant species, such as sheep with high growth potential. These farmers can provide a safety net in case of haz-

ards. Using a model built in the framework of the viability theory, authors scanned available management options to build resilient trajectories. This example could be a relevant approach. Identifying management options to ensure long-term respect of predefined constraints (income and subsistence consumption of livestock products) could be used in European agriculture to study how different robustness traits of dairy cows can improve the long-term stability of milk production, in the face of global change. Letaief and Bedhia (2022) presented how a better knowledge of camel breeding is important to understand the choice of breeders. Also, the implementation of a modern selection system for morpho-functional traits of economic interest will help increase camel productivity in North Africa. It also suggests the importance of laying the foundations for a reflection on the improvement of milk production as a source of resilience of the herds.

The role of genetic diversity is very important Brito *et al*. (2022) showed how the analysis of two local breeds morphometric parameters are the result of the adaptability to different ecosystems and the environment influence by breeds adaptation (*Bordaleira de Entre Douro e Minho* and *Churra do Minho*). The authors also explain the crucial role of rural policies in promoting local genetic resources and enhancing sustainable products. Breed adaptation and selection are the two parts of genetic resources management and valorization. Perucho *et al*. (2022) highlight how two dimensions are involved in the adaptation of livestock. The first concerns the specific properties of animals –or animal populations– and the second the dynamic process of their maintenance in the environment. Using several case studies of local sheep breeds in the French Mediterranean region (*Corsican*, *Raïole, Caussenarde des Garrigues* and *Rouge du Roussillon* sheep breeds), it is shown that the objectives of the two approaches are different. The first approach is based on the biological characteristics of the animals, while the second approach focuses on human practices and their interrelationships with the animals. Finally, the authors show that while the risk of the first approach is to limit the question to biological characteristics, the second, more complex approach invites us to understand how actors manage this adaptation at a collective level and to consider the diversity of levels involved. However, these two approaches are complementary and require multidisciplinary research.

The breeding practices implemented by the farmers are one of the means of adapting the system to hazards. Benoit *et al*. (2020) argue that the resilience of sheep farms is determined by internal mechanisms of adaptation to technical and economic hazards. They proposed a modelling approach to assess key performance indicators responding to technical and market hazards on five contrasting meat sheep farms in France and Ireland. The hazards were associated with three key technical variables (ewe fertility, prolificacy, lamb mortality) and four economic variables (price of two types of lamb, concentrate use, energy use). The authors analysed the links between breeding behaviour, input level and income variation. Overall, they showed that variations in technical variables had greater effects on income variability than those in economic prices. The very high potential prolificacy and highly variable lamb mortality may explain this. For them, the most resilient systems, i.e. with the lowest variation in net income, are those that combine a low level of inputs and at least two lambing periods per year.

Beyond the practices implemented by the farmers, in the most difficult areas, economic performance is also linked to the types of products marketed and the characteristics of the farm. This is the purpose of Angerer *et al*. (2020) who have studied how in the south Tyrol of Italy, beef production could be an alternative to milk production to increase the income of small mountainous farms. The objective of the study was to evaluate the economic results of 34 farms divided into two meat systems: (i) suckler cow rearing and (ii) heifer/beef fattening. The role of subsidies is essential for the results to be positive for the vast majority of farms. This leads to the conclusion that beef production is currently not profitable for small mountain farms. Consequently, cost reduction strategies (e.g. collaboration between farmers) and marketing programmes are needed to reduce costs on the one hand and to increase prices on the other hand. This point implies that it would be interesting to study the anchorage of the management systems with the territory.

III – Territorial anchorage as a socio-technical lever for transition

Many livestock farming systems in the Mediterranean, mountainous or less-favored areas are linked with their territory. The anchorage is based on natural resources, PDO products, and on the social environment. Martel *et al*. (2020) explained how territorial resource mobilization shapes agroecological transitions in crop-livestock systems. The authors explore 8 farming systems in 4 different territories to highlight the role of resource diversity in the sustainability of farming systems. In each territory, a baseline system and an agroecological system are compared. Four types of territorial resources are studied: natural, technical, social and economic (local communities). The two systems combine different resources. The agroecological systems rely on resources linked to a local territory and based on biodiversity, while the other systems are interested in resources that allow global exchanges and require inputs. The diversity of the resources mobilized makes it possible to duplicate certain knowledge and increase their resilience to changes in resources in the territory.

One way of strengthening economic resources is the maintenance of added value in the territory of the less-favoured agroecosystems. Orsi *et al*. (2020) studied how local sheep breeds (*Lamon* and *Alpagota*) contribute to this maintenance of the added value of Italian Alpine agroecosystems. These small-scale mountain farms seek to develop their production in connection with a "territorial marketing" strategy or for example with a cooperative with quality products design as Slow Food "Ark of Test". For the authors, the resilience of small ruminant farms can be strengthened by involving small farmers in cooperative/multi-stakeholder approaches that aim to conserve Alpine sheep breeds.

Livestock dynamics in mountain regions were presented by Muñoz-Ulecia *et al*. (2020) as complex interrelationships between human and environmental systems. The analysis of the trajectories, over the last 30 years, of 50 cattle farms in the central Pyrenees in Spain showed that general changes have transformed the systems: changes in the main orientation of production; other changes related to the technical and labor organization of these systems. The authors have also identified the role that the different valleys play on these dynamics. Each valley is a place of socio-technical organization subject to political or socio-economic transformations. The resilience of farms is presented as being influenced both by internal social factors at the farm level and by external political factors at the EU level.

The role of livestock partners is essential in anticipating transformations and supporting transitions in livestock production. It is on this point that Accatino *et al*. (2020) agree in assessing the resilience of extensive grass-based cattle breeding systems. Defining resilience as a combination of robustness, adaptability and transformability, the authors use interviews, participatory workshops and focus groups to identify livestock challenges and transition strategies. The main challenges were economic, social and environmental, and stakeholders were mainly concerned with developing the robustness of livestock production to hazards. Fewer strategies were devoted to improving adaptability or transformability. The strategies suggested by stakeholders for future implementation were mainly focused on adaptability.

By looking at traditional livestock farming societies in Mongolia and the Andes and analysing their proximity to the agroecological framework, Joly *et al.* (2020b) identified what Western livestock systems need to do to make the agroecological transition. In addition to reducing inputs, closing geochemical cycles and mobilising diversity, the authors pointed out the shortcomings of traditional systems that need to be addressed by our livestock systems. The first issue is the reduction of workloads, linked to the use of a diversity of resources. Secondly, the preservation of resilience could be achieved by optimising production, but also by reflecting on the phenotypes of the breeds. Where breeding systems try to react to hazards, the authors suggest that breeders anticipate global changes. Finally, they raise the question of how western breeders view these traditional systems which seem to have developed alongside agricultural notions of modernity. This could become an obstacle to the Transition.

IV – Conclusions

Addressing the challenge of adapting livestock systems to climate change (Altieri *et al*. 2016) and meeting the growing demand for animal products (Motet *et al*., 2017) is the agenda for animal scientists in the years ahead. The transition of livestock sector towards agroecology (Magne *et al*, 2019) and resilient systems (Lamine, 2015) is one of the pillars of the Farm to Fork strategy (Wezel *et al*., 2016), and it is an urgent need in particular for Mediterranean and marginal agro-ecosystems. The contributions presented in session 37 of EAAP 2020 offered a broad view on the role of diversity of resources and farming practices to ensure resilience of livestock farming systems at different scales. The researches needed to favour this process should be based on multidisciplinary approaches, considering different scales of analysis and with a strong involvement of relevant stakeholders.

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Diversity of animal genetic resources for resilient farming systems

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Abstract. The diversity of animal genetic resources is an important factor in all efforts to ensure resilience of farming systems at different scales, especially if combined with differentiated farming practices. This article provides an overview of the aspects and conclusions presented during session 47 of the Annual Meeting of the European Federation for Animal Science (EAAP) that took place on a virtual platform in December 2020. A concise account of major research efforts of various teams under specific categories is presented, along with main and common conclusions drawn. Through research findings and the discussion that ensued during Session 47, the need for further and more extensive collaboration among research teams, countries and regions was stressed once more. In addition, certain themes arose to stimulate future research in this area.

Keywords. Animal Genetic Resources – Diversity – EAAP2020 – Resilience.

Diversité des ressources génétiques animales pour des systèmes agricoles résilients

Résumé. *La diversité des ressources génétiques animales est un facteur important de résilience des systems d'élevage à différentes échelles, en particulier si cette diversité est associée à une diversité de pratiques de gestion. Cet article décrit les différents éléments et conclusions présentés dans la session 47 de la Conférence Annuelle de la Fédération Européenne de Zootechnie (EAAP) qui s'est déroulée sur une plateforme virtuelle en décembre 2020. Il synthétise les principaux efforts de recherche menés par différentes équipes dans des catégories spécifiques, ainsi que les conclusions majeures et communes aux différents travaux de recherche. Les résultats présentés lors de la session 47 et les discussions qui en ont découlé soulignent une fois de plus la nécessité d'encourager et de renforcer la coopération entre les équipes de recherche, entre les pays et entre les régions. Enfin, certains thématiques ont été évoquées pour stimuler de prochaines recherches dans ce domaine.*

Mots-clés. *Ressources Génétiques des Animaux – Diversité – EAAP2020 – Résilience.*

I – Introduction

Livestock diversity facilitates the adaptation of production systems to future challenges and is theoretically a source of resilience in the face of greater climatic and socio-economic variability. Diversity in livestock production systems may be considered at all scales, from individuals and breeds to species and ecosystems.

The presentations of the Session 47: *Diversity of animal genetic resources for resilient farming systems, (2nd part of the Full day Workshop of EAAP 2020 under the general title:* "**Combining the diversity of resources and farming practices to ensure resilience at different scales"**), focused on the challenges and drivers of change (socio-technical, socio-economic and environmental aspects) that the livestock sector faces in the Mediterranean and other less-favoured areas. The Workshop was initiated by the EAAP Mediterranean Working Group and organized jointly with the Livestock Farming Systems Study Commission. The various authors provide information on several issues related with the diversity of animal genetic resources, their capacities to express a good balance between production, reproduction, health performance, and/or to valorize scarce and diverse feed resources.

This article provides a general overview of the recent developments related with the potential contribution of animal genetic resources to the development of resilient farming systems. The article is structured in three sections, dealing with (i) the impact of climate change on breed resilience and adaptation, (ii) methodological approaches and genomic selection and (iii) gene-banking strategies with particular reference to the implications for local breeds and resilient farming systems, connected also with monitoring and documentation aspects.

II – Climate change aspects, breed resilience and adaptation

Several constraints due to climate change impede the sustainability of livestock production in the Mediterranean basin. The ability of livestock to breed, grow, and lactate to their maximal genetic potential, and their capacity to maintain health is strongly affected by climatic features and the Mediterranean region has been identified as a highly susceptive region to climate change and accompanying systemic failures.

In this context, Karatzia *et al*. (2022) assessed the response of a local sheep breed (the Karagouniko sheep breed) managed in extensive or semi-extensive systems at different stressors that compromise animals' welfare. The study was initiated by the existing needs to reintroduce Karagouniko breeding males in highly productive crossbred flocks) aiming to improve the flock response to some constraints of the biophysical environments, such as the sensitivity to thermal stress (Perucho *et al*., 2019). Selection on heat tolerance is challenging due to the complexity of heat stress response and the antagonism between heat tolerance and productivity. Thus, breeding strategies to improve heat tolerance vary according to the production system.

Stakeholders, and mostly the breeders, seek to improve the resilience and the ability of adaptation of their animals. Resilience could be understood, as the ability of the animals, to undergo minimal perturbation from their performance trajectory and to get a fast recovery when submitted to an environmental challenge (climatic, disease, nutritional, restriction etc.), while adaptation is the ability of the animals to live, breed and perform in their pedo-climatic environment and traditional system of production (Astruc *et al*., 2022).

Locally adapted breeds in warm environments have developed specific characteristics that allow the potential use of these breeds adapted to harsh conditions to improve thermotolerance of more productive breeds when farm resources and animal health are not limiting the survival of highly selected breeds (Carabaño *et al*., 2019). Several research efforts focus on phenotyping to identify heat tolerant animals on farm and on developing methods to combine the knowledge from all "-omics" technologies. Reaction norm models are useful tools to characterize resilience of farm animals to extreme weather conditions (Carabaño *et al*., 2020).

Further to the above, when dealing with local breed adaptation, we should not only focus on animal characteristics but also take into account social and technical dimensions of adaptation. The study of Perucho *et al*. (2021) discuss this topic with the example of four French Mediterranean sheep breeds. Specific farmer-led breeding practices to improve flock adaptation to biophysical constraints illustrate that several levels of organisation play a role, both at the farm scale and at the collective breed management scale.

Letaief and Bedhiaf-Romdhani (2022), describe the national efforts to improve camel breeding in Tunisia. In Southern Tunisia, camels are traditionally reared under pastoral production systems and they are mainly herded for meat production. Camel milk is characterized by its therapeutic value, yet its sale is always considered a taboo. Camel keepers are facing various constraints such as high feeding costs, diseases and jackal attacks. For future prospects, national efforts should be made to convince camel owners to invest in milk. Furthermore, other research should be conducted to identify the genetic potential of Tunisian camel for milk and meat production in order to use this information for genetic improvement.

III – Methodological developments and genetic/genomic applications

This section of the session has focused on presentations exploring various methodological approaches and the implementation of genomic characterization and improvement of various local breeds.

A simulation approach of differentiated extents of crossbreeding and heterosis effects to explore the effective use of rotational crossbreeding as a means to increase within-breed genetic diversity in the Holstein cattle breed and whole herd performance was presented by Quénon *et al.* (2020). Croué *et al*. (2020) pursued and tested the development of a software to determine breed of origin per allele for three-way dairy crossbred cattle, in order for the crossbred population to be included in genomic evaluations. Further, another study explored imputation accuracy of various tools in cross-bred dairy cows from Normande and Holstein crossbreds, as part of the GenTORE project (Maugan *et al*., 2020). FImpute was found to be the most suitable one for crossbred animals, and imputation for crossbred dairy cattle was deemed feasible for the purpose of routine genomic evaluations.

In the study by Ginja *et al*. (2020a), multi-source genetic markers were used to genotype over 4500 individuals from 114 cattle breeds distributed worldwide, in order to assess the ancestry, genetic diversity and historic admixture of American Creole breeds. Genetic influences were identified both from the Iberian cattle and by African cattle. These findings stressed the need for conservation of these unique genetic resources and for the state-of-the art genomic tools to become available for undervalued breeds, such as the Creoles, kept in marginal regions.

In a research study within the OPTIBOV project, copy number variation (CNV) mapping was used for 120 whole genome sequences from five traditional Dutch cattle breeds and five individuals of the Holstein Friesian breed, to assess genetic variation and identify functional genes. Substantial variation in CNVs was observed among breeds. Thus, further study of genes underlying the breed-specific CNVs will be conducted (Gonzalez-Prendes *et al*., 2020). Furthermore, within the OPTIBOV project, genomic characterization of three Portuguese native cattle was pursued to explore optimal performance, through identification of markers for ecosystem adaptation and disease resistance in addition to production trait improvement (Ginja *et al*., 2020b). Future deliverables of these efforts will be a genotyping assay for more diverse traditional cattle and for improvement of breeding programmes. Within the same project, a whole-genome scan of sequence data for selective sweeps in three South African indigenous cattle breeds (Afrikaner (16), Nguni (24), Tuli (10)) was performed to explore the genetic basis of their adaptive characteristics to local climate conditions and tolerance to tick-borne diseases (Makgahlela *et al*., 2020). Putative selective sweeps were identified across the breeds, with 233 putative regions. Gene ontology identified genes related to skin pigmentation, coat colour and fertility, and provided an insight to genetic mechanisms that influenced selection in these breeds.

In French dairy small ruminant local breeds, breeders are increasingly addressing the issue of selecting more adapted and more resilient sheep and goats. Global warming, new health challenges, and societal demand for more agro-ecological and sustainable systems are strong drivers and incentives for this impetus. Novel adaptation and resilience-related traits have been / are under study, thanks to various projects. Some of them might rapidly be / are already included in selection criteria. Building more balanced breeding goals should benefit from more efficient genomic selection and also from international cooperation. This puts an emphasis on the importance of joining research and development, and academics' and stakeholders' input (Astruc *et al.*, 2022).

The AGRICYGEN project presented during session 47, is an ongoing interdisciplinary project for genomic evaluations to improve the whole system of small ruminants in Cyprus (Hadjipavlou *et al*., 2020). This entails genomic studies of Cyprus Chios sheep, Damascus goats, crops and legumes grown for animal feed and soil microorganisms that improve crop growth performance and quality, while enriching Cyprus soils in an ecological manner.

IV – Gene banking and documentation

Gene banks as the reservoirs of genetic diversity can offer several options for the future, supporting various and more resilient farming systems. The role and implications of Gene Banking strategies towards strengthening the livestock sector to respond to the new challenges was addressed within the IMAGE project. Tixier-Boichard *et al*. (2020) presented the outcomes of IMAGE relevant with the links of Gene Banks and local breeds management. Three key questions were addressed: 1) how to characterize adaptation, 2) the optimization of gene banking cost, and 3) the commitment of policy makers. The additional constraints that local breeds are facing on the collection process for Gene Banks, either because they are raised in remote areas, their health status is poorly known, or they face problems due to inbreeding were discussed. Furthermore, the establishment of a multi actor decision-making body (including scientific experts on genetics and reproduction) will ensure the efficient functioning of Gene Banks.

Several aspects of cooperation and coordination between countries were raised, concerning not only Gene Bank management, but also the monitoring and documentation of livestock breeds. In this direction, the European Focal Point (ERFP) WG Documentation and Information and the EAAP Mediterranean WG have initiated activities to stimulate interaction and cooperation in the region in aspects related with the documentation of AnGR. Ligda *et al*. (2022) present a preliminary analysis of the status of AnGR documentation in the Mediterranean region, by analysing specific country datasets from DAD-IS. The analysis of the data showed the wide variation between countries, but also between species within country. This variation reflects the changes in policies and priorities in the country and the level of organization in each livestock sector. The various gaps, either related to the lack of sufficient structure(s) for population monitoring and data flow organization or on knowledge gaps on the breed characterization, need oriented approaches and cooperation within and across countries, and among various stakeholders.

V – Conclusions

The efficient management of animal genetic resources (AnGR) remains a challenging task that requires deep knowledge of the populations, as well as sufficient monitoring systems that will allow the implementation of sustainable breeding programs and will ensure the conservation of AnGR for a viable future.

Within Session 47 of EAAP2020, the need to strengthen the within-country (stakeholders), across countries, regional and international cooperation was emphasized, through research initiatives towards enhancing the genetic characterization and breed /population management under contemporary conditions and specific pressures. For this objective, it is important to mobilize funds from national, regional, international research collaborations and breeding schemes.

Themes for ongoing and future research collaboration arose, such as the implication for sheep and goat breeds facing extreme temperatures (too high or too low) at various times of the year, not just heat stress, other health challenges, societal demands and the need to create agro-ecologically sustainable systems. Breed resilience due to genetic background and how to identify it was also discussed, focusing also on the measurable heat and other stressor indicators that could be used in selection programmes. The study of local breed adaptation requires interdisciplinary, as well as participative approaches that will consider farmers' viewpoints and practices. Finally, it was stressed that Gene Banks can serve several objectives, such as to re-introduce lost genetic variants, increase variability and re-orient breeding objectives. In this context, participants agreed that adequate training in gene banking management is highly needed and that the creation of genebanks must be done before local breeds become endangered.

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A Brazilian initiative for sustainable development of smallholder dairy farming: the PISA Program

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Abstract. In the context of a growing demand for food in the near future, scarcity of natural resources and climate-change, the PISA program was designed to promote sustainable development of agricultural systems. In this article, we present a detailed description of PISA, as well as a case study of one of PISA's projects, in which we assessed sustainability. Ecological intensification is the base of PISA philosophy, comprising several tools and technologies on its conceptual framework. PISA execution methodology provides a context-specific and flexible-holistic approach. PISA is operated as an agricultural extension program, that has already served 1819 farmers in Southern Brazil. In the State of Rio Grande do Sul, PISA has been implemented in a more concrete way, through a public-private partnership aimed at smallholder dairy farming. In the case study of PISA Norte project, sustainability assessment by an international validated tool (SAFA) was performed in all supported farms. Smallholder dairy farmers, from the PISA Norte project, presented good performance in all sustainability dimensions. PISA principles, practices, and results addresses relevant sustainable development goals from the 2030 Agenda. Although PISA has been largely executed in smallholder dairy farms, its conceptual framework and institutional structure for operation can be replicable to any agrifood system.

Keywords. Agricultural development – Sustainable intensification – Ecological intensification – Rural advisory Services – Sustainability assessment.

Une initiative brésilienne pour le développement durable de la petite production laitière : le Programme PISA

Résumé. *Dans le contexte d'une demande alimentaire croissante dans les années à venir, de la rareté des ressources naturelles et du changement climatique, le programme PISA a été conçue pour promouvoir le développement durable des systèmes agricoles. Dans cet article, nous présentons une description détaillée du programme PISA, ainsi qu'une étude de cas d'un des projets de ce dispositif et pour lequel nous avons évalué la durabilité des fermes. L'intensification écologique est la base de la philosophie du programme PISA : cela comprend dans son cadre conceptuel plusieurs outils et technologies. La méthodologie d'exécution du programme PISA fournit une approche spécifique du contexte et une approche holistique flexible. Le programme PISA fonctionne comme un dispositif de vulgarisation agricole, qui a déjà impliqué 1819 agriculteurs dans le sud du Brésil. Dans l'État du Rio Grande do Sul, le programme PISA a été mis en œuvre de manière plus concrète à travers un partenariat public-privé visant les petits exploitants producteurs de lait. Dans l'étude de cas du projet PISA Norte, l'évaluation de la durabilité par un outil validé au niveau international (SAFA), a été réalisée dans toutes les exploitations agricoles suivies. Les petits producteurs de lait du projet PISA Norte ont présenté de bonnes performances dans tous les domaines de la durabilité. Les principes, les pratiques et les résultats du programme PISA, répondent aux objectifs de développement durable fixés dans l'Agenda 2030. Bien que le programme PISA ait été largement mis en œuvre dans les petites exploitations laitières, son cadre conceptuel et sa structure institutionnelle de fonctionnement peuvent être reproduits dans n'importe quel système agroalimentaire.*

Mots-clés. *Développement agricole – Intensification durable – Intensification écologique – Conseil agricole – Évaluation de la durabilité.*

I – Introduction

The process of agricultural modernization has led agrifood systems towards specialization and high input dependence, such as fertilizers and pesticides, resulting in side-effect environmental impacts. Considering the projection of population growth and increasing number of people without regular access to safe, nutritious, and sufficient food, there is a rising demand for food production through sustainable intensification, coupled with the creation of local strategies to tackle global food insecurity. According to Beltran-Peña *et al*. (2020), to meet this growing demand for food, besides sustainably increasing production, sustainability and resilience aims must be initiated to cope with the climate change scenario, added to scarce raw materials and economic instability. The alternative proposed to overcome these challenges, defined as "sustainable intensification", consists in increasing food supplies, without expanding land use for agricultural production, based on the improvement of the economic, social, and environmental pillars, which compose sustainability (Garnett *et al*., 2013; Thomson *et al*., 2019). However, the transition of agroecosystems in search of sustainability requires customized solutions, as agricultural systems management and planning, depending on site-specific environmental and socioeconomic conditions (Teixeira *et al*., 2018; Peltonen-Sainio *et al*., 2019; Titonell, 2020).

Diversified agrifood systems are essential in the process of transition towards practices promoting food security and sustainable intensification (Gaba *et al*., 2015). In this context, integrated crop-livestock systems (ICLS) were recognized as an alternative to achieve sustainable intensification (FAO, 2010), as these systems entail diversification. Additionally, many aspects of the ICLS are considered important features to the modern concept of sustainable intensified agricultural production (Moraes *et al*., 2014). For instance, on within-farm ICLS, proper grazing management maximizes both forage and animal production (Kunrath *et al*., 2020), while potentially reducing greenhouse gas emissions (de Souza Filho *et al*., 2019). The integration of crop and livestock provide positive modifications in the agroecosystem, such as enhancing soil physical, chemical, and biological attributes (Peterson *et al*., 2019), and improving nutrient cycling and resource-use efficiency (Szymczak *et al*., 2020).

In this context, the PISA program was designed, having the ICLS as a major conceptual pillar. Aiming to improve sustainability of agriculture, this initiative involves the development of crop-livestock integration along with the implementation of agricultural technologies and practices according to specific contexts and based on a holistic approach. PISA was introduced as an agricultural extension program, which has already served 1819 farms since its creation. In this article, we present a detailed description of the PISA initiative, as well as a case study of one of PISA's projects, in which we assessed sustainability by an international validated tool.

II – The PISA Program to support sustainable development of smallholders

1. PISA genesis and its scientific foundations

The Integrated Production in Agricultural Systems, hereinafter referred to as PISA (its Portuguese acronym for *Produção Integrada em Sistemas Agropecuários*), was conceived, developed, and institutionalized as a program in 2007 by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA, its Portuguese acronym). The program was technical and jointly coordinated by the Federal University of Paraná (UFPR) and the Federal University of Rio Grande do Sul (UFRGS). The objective of the program was officially presented as: "to promote sustainable development within the scope of the micro-watershed, as a basic planning unit, through the diffusion of sustainable technologies and transformation of the production process, to obtain safe, quality food, with competitiveness, and job and income generation" (BRASIL, 2009).

The philosophy of PISA was firstly based on the general concept of ecological intensification, meaning intensifying the functionalities of natural processes that agricultural ecosystems can offer (Doré *et al*., 2011). PISA aims to be as flexible as to adapt to any food production system in any part of the world. To accomplish parallel goals such as optimizing land use, saving smallholder farmers' workloads, enhancing farm productivity, or increasing farm profitability, different tools and practices must be combined in a holistic and flexible site-to-site approach. To this end, the program makes use of different technologies and processes, customized for different context-specific solutions, to build sustainable and competitive food production environments. The PISA management framework can draw on a variety of scientific approaches and technologies, such as ecological intensification, conservation agriculture, functional diversified farming, integrated crop-livestock systems, silvopastoral systems, animal welfare and health, climate smart-agriculture, rotatinuous stocking, farming system design; economic tools and controls; system fertilization approach; nutrient recycling; agricultural best management practices; circular economy.

Therefore, conceptual foundations of PISA, originated from the academic world, must be associated with governance led by MAPA to build a program aimed at diversifying and strengthening agricultural production and achieving food security. The mediation of public and private institutions, as well as representations of civil society, constitutes a collaboration strategy adopted in PISA, seeking convergence on the interests of food production and conservation of natural resources.

2. Running the PISA Program in Southern Brazil

In 2009, PISA philosophy and technical pillars were applied in a smallholder dairy farm in the state of Rio Grande do Sul to serve as a PISA implementation model, and furthermore, as a Technical Diffusion Unit (UDT) to other farmers. Since 2012, PISA has been operated as an agricultural extension initiative in the South Region of Brazil. Smallholders from 1819 farms, in 119 municipalities in the Southern States of Brazil (Paraná – PR, Santa Catarina – SC, and Rio Grande do Sul – RS), have already participated in the PISA program. In RS, the program has been more extensively executed, accounting for 95 municipalities, from 2012 to 2020 (Fig. 1).

The broader execution of PISA Program in RS was made possible due to its institutional arrangement, performed by a public-private partnership. In 2011, under the guidance of the UFRGS, the SEBRAE[1] joins PISA in the RS, by including PISA in the portfolio of a broader action aimed at the development of agricultural productive chains (JC program[2]).

JC performs PISA as local agricultural extension projects, aimed at smallholders' dairy farms. Projects are designed as a collective initiative, in which smallholders join voluntarily. Each PISA project is organized in steering committees with local actors, such as policy makers, NGOs, local associations, etc. The committee is responsible for guiding the implementation of the project. The rural advisory service for the projects is performed by an outsourced consultancy company hired by the JC. Therefore, the institutional arrangement of PISA projects is composed of the institutional founders, the institutional operators, the private consultancy company, and the local government.

Each PISA project covers a microregion of RS, comprising from 5 to 10 municipalities. In general, there are 15-20 beneficiaries in each municipality. Hence, projects' beneficiaries ranged from 60 to 150, depending on the local context, local demand, and farmers adherence.

1. Brazilian Micro and Small Business Support Service – private-sector institution.
2. The JC program, Portuguese acronym for *Juntos para Competir*, is a partnership among the Agriculture Federation, the National Rural Apprenticeship Service (SENAR) and SEBRAE-RS.

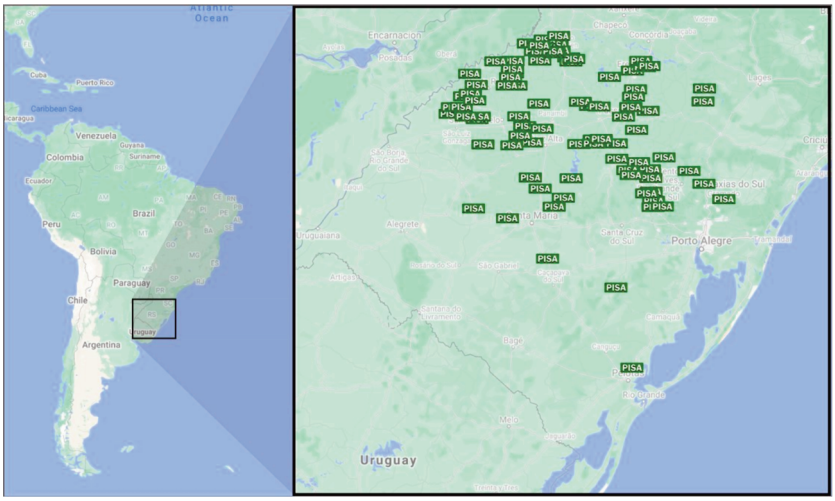

Fig. 1. Municipalities of the Rio Grande do Sul State where PISA has been executed, from 2012 to 2020.

A. PISA project execution plan

PISA projects are designed for a duration of 3 or 4 years. The PISA's rural advisory services include regular 4-hour technical monitoring service for farmers on the spot and group training activities. PISA execution methodology provides the implementation of a model unit called Technical Diffusion Unit (UDT) for every group of 15-20 farmers (generally one UDT per municipality). In the UDT, the application of PISA's concepts and tools can be demonstrated as practical results to all group. Considering UDTs' purpose, farmers receive monthly technical visits from field advisors. The other PISA farms, called "production units" (UP), are assisted every 45-60 days, throughout the progress of the project. Among the actions of collective training, farmers are encouraged to participate in the regular meetings, lectures and short courses that take place at the UDTs or local institutions facilities, in which they can build capacities and exchange ideas and experiences.

The implementation of a project is based on a request from a local actor, such as municipal departments, agents from the governmental company for agricultural extension (Technical Assistance and Rural Extension Company – EMATER), trade unions or farmer organizations, or dairy companies. From this request, the PISA project's committee is set. Farmers are invited to take part in the project by local actors, and the project's proposal is exposed to them. Thus, the groups of farmers that constitute a project are voluntarily formed, which is a prominent point for the rural extension process. The choice of the UDTs is also led by a participative and collective initiative since farmers and field advisors take part in the decision.

Regarding rural advisory services, field advisors from the hired consultancy company are trained to assure an even level of expertise in PISA's conceptual framework and philosophy. Advisory practice is performed in a participative approach, in which the field advisor works with farmers to establish a consistent and trust farmer-advisor relationship. In this context, advisors' recommendations, based on PISA's tools and practices, are adapted to each assisted farm reality, co-conceived with farmers, to empower farmers to make informed decisions and adopt suitable practices.

B. Target audience of PISA projects

In the State of Rio Grande do Sul (RS), milk production is an important economic activity, it is a formal economic activity in 90% of the state's municipalities. According to a recent report on the dairy production chain (EMATER-RS, 2019), more than 90% of milk produced in the RS State involving 50.500 dairy farmers, is sold as raw milk to official milk marketing channels. Among these dairy farmers, 97,5% are family farmers, with an average land area of 18 hectares. Milk is mainly produced in pasture-based systems (95% of farms), with an average herd size of 18 cows per farm. Most of the dairy herds (95%) comprise Holstein, Jersey and Holstein-Jersey crossbred cattle. Around 75% of those dairy farms produce up to 300 L of milk a day. These features are very consistent with the dairy smallholders observed in the PISA farms before technological intervention, i.e., before the implementation of a project.

Indeed, in accordance with this report, the PISA farms milk production is usually the main source of income for PISA farmers. Most of them are family farmers with forage-based dairy farms, where milk production is carried out in small production units. On average, the total land area is around 15-20 hectares with 6.5 hectares for grazing area. Farms present an average of 18 milking cows with a productivity of 18 litres per day. However, we highlight the wide diversity in PISA farms regarding soil characteristics, breeds of dairy cattle and crop diversity, family ethnical origins, farm structure, etc.

For instance, the PISA Norte project was designed to assist six municipalities from the North microregion of RS (Campinas do Sul, Erechim, Getúlio Vargas, Sertão, Três Arroios and Viadutos). The project was requested by local actors based on the regional importance of the milk production chain, the need of advisory services for dairy smallholders, and the increasing number of producers leaving dairy farming, which has turned into a low sustainability activity. From 2016 to 2020, the project was supporting 79 dairy farmers.

III – Sustainability assessment: Case study – PISA Norte Project

Considering that sustainable development is a driving goal of the PISA Program, in this case study, we assessed farms sustainability of one of PISA's projects, the PISA Norte project.

1. Methodology for assessment

We used an internationally validated assessment tool, the SAFA Smallholders App (version 2.0.) to assess sustainability of the PISA's farms. This tool was designed to support the applicability and implementation of SAFA Guidelines (FAO, 2014) at small-scale farms. SAFA Smallholders App consists in a 100-questions survey. That survey comprises a set of 44 indicators that are both highly relevant and practical to smallholder farmers, distributed in 21 SAFA themes and four dimensions of sustainability (good governance, environmental integrity, economic resilience, and social well-being).

For this study, SAFA Smallholders App survey was adapted since the app is no longer available. Questions were transcribed into a spreadsheet. The calculation of indicators and themes rating follows the same rules applied by SAFA Smallholders App. For each theme, a mean index was calculated based on all PISA Norte project's farms ratings. The SAFA sustainability polygon was created from the calculated mean index of the 21 SAFA themes.

In October 2020, at the end of the PISA Norte project, a two-hour interview was carried out on site by a trained interviewer in the 79 farms of the Norte project to apply the SAFA survey. The main farmer in charge of the milk production was surveyed. Interviewees could express themselves comfortably, with no interference or judgment from interviewers. During the interview, a farm tour was requested to interviewees, to understand the context of the farm.

2. Results from the sustainability assessment of the PISA Norte project

By the end of the project, PISA smallholder dairy farmers presented good performance in all sustainability dimensions (Fig. 2).

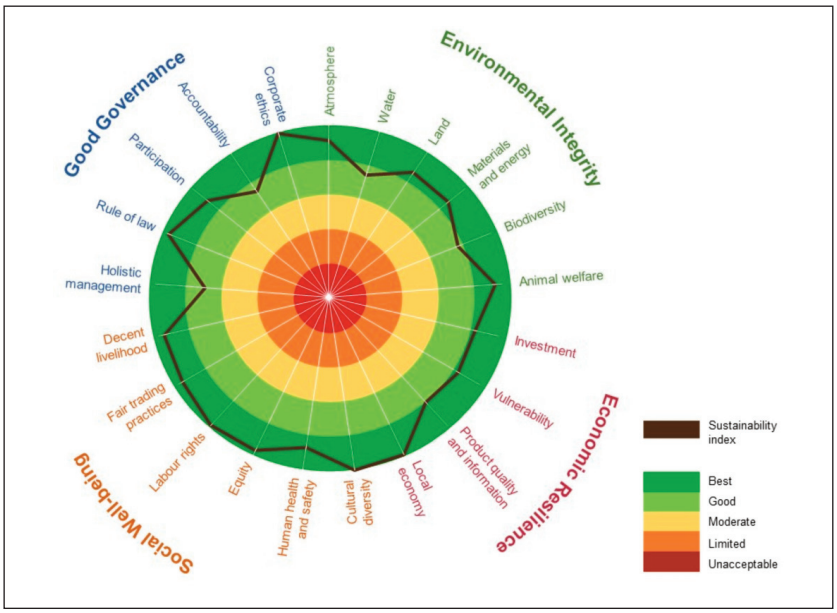

Fig. 2. SAFA sustainability polygon presenting the mean sustainability index of all farms of the PISA Norte project.

We observed an important impact of the PISA project on good governance. The SAFA tool has integrated this dimension in the sustainability analysis, considering governance as the process of organizing and implementing decisions, related to the other three pillars of sustainability. Thus, the project has provided to farmers a new holistic view of the farm and the dairy production system. This new guiding vision, understood in terms of values and goals of the PISA project, was assimilated by 95% of PISA farmers (corporate ethics theme). However, technical recommendations from field advisors and knowledge shared with farmers by the project initiatives were adopted, to a greater or lesser degree, among the assisted farms.

Regarding accountability, which is commonly overlooked in family farming, in 50% of PISA farms, producers have assiduously kept accurate production records. This activity has been also carried out in a lesser detailed and frequent way in 35% of the farms. Records represent a key tool for the holistic management.

Within the economic resilience dimension, we identified PISA project's contribution to enhance farms' profitability. More than 80% of PISA farmers reported that the farm revenues have often been greater than costs. This result is related to improvements in the dairy production system, that promoted increase in milk production, and / or reduction in milk production cost, assuring a higher profit margin to farmers. The new concept of grazing management, combined with adequate forage planning and animal nutrition, were pointed out by most PISA farmers as the main drivers of changes in their production systems. Another positive aspect related to cost reduction is that it allows farmers to face the fluctuation of milk prices with greater resilience.

For the vulnerability theme, the most prominent outcome is that 75% of PISA farmers have implemented on-farm measures to reduce risk due to PISA advisors' recommendations.

Considering the environmental dimension, in the atmosphere theme, we highlight as relevant practices for mitigating greenhouse gases, the adoption of rotatinuous stocking (Carvalho *et al*., 2013; de Souza Filho *et al*., 2019) and no-tillage as the main cultivation method, observed in most PISA farms. For animal welfare, in 95% of PISA farms best level of well-being and living conditions of animals were observed. Related to materials and energy theme, PISA farmers reported an improvement in soil fertility management. In 82% of PISA farms, fertilizers have been more efficiently used. In addition, most farms maintain a permanent soil cover. All PISA farms present a preserved natural vegetation area (permanent set-aside, defined by Brazilian legislation); and most farming systems produce multiple types of crops and pastures, along with livestock, justifying the good level for the biodiversity theme. We highlight that diversification, and the use of locally adapted crops and pastures are encouraged by PISA's field advisors.

Important impacts of the project were observed in the decent livelihood theme, within the social welfare dimension. The PISA project provided farmers with access to new knowledge, through trainings, meetings, lectures, and exchange of experiences with filed advisors and other farmers, favoring the development of PISA farmers' capacity. In 99% of the PISA farms, some degree of improvement on the producers' quality of life was reported.

IV – Final considerations

We identified that PISA stands out in terms of human resources. Farmers are supported by qualified field advisors, who are constantly being updated and can articulate multidisciplinary knowledge. In this sense, PISA advisors strengthen the link between research and farmers. To rural extension, these are desirable features in the context of more complex agricultural systems to deal with a challenging future scenario of climate change and economic instability. Additionally, we underline the combined actions of individual and group advising, performed in a participatory approach, as an important strategy towards the change of farmers mindset.

A new mindset opens to changing practices, so the transition to self-sufficiency can occur. The conversion from a specialized trajectory input driven to a diverse on-farm resources based on the PISA philosophy has proved sustainable in all dimensions by the SAFA tool.

The institutional arrangement of the PISA projects plays a prominent role in achieving goals. Each actor involved contributes to successfully implement a project, among the activities of promotion, financial support, management, theoretical-practical guidance, and execution. That explains the long-lasting and broad execution of PISA in the RS.

The PISA scope is aligned with the 2030 Agenda for sustainable development (UN, 2015). For instance, PISA principles and practices meet relevant sustainable development goals (SDGs), from promoting food security, social well-being, and sustainable economic growth to responding to climate change and sustaining our natural resources. PISA initiative actions are interconnected to address sustainable development, and hence, meet important SDGs.

At last, it is worth noting that, for the case of the RS, PISA is performed in smallholder dairy farms. However, PISA's conceptual framework and institutional structure for operation can be replicable to any agrifood system.

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Adaptation of local breeds is not only a biological question: Illustration with four French Mediterranean sheep breeds

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Abstract. Local breeds of domestic livestock have been promoted for long for their adaptation to specific farming conditions involving an exposure of the flock/herd to various biophysical constraints. Although largely underlined in recent research studies, adaptation of local breeds is few informed for several local breeds of the Mediterranean area, including for sheep breeds of the North Mediterranean shore. Moreover, in this region submitted to increasing market uncertainties and biophysical constraints, there is a need to adopt a broader approach of adaptation and consider adapted genetic resources as genetic resources shaped by human practices with the aim to take part in the resilience of livestock farming systems in a context of global changes. This paper rests on illustrations taken from two case studies in France, involving four Mediterranean local sheep breeds. We first identify the modalities of management of the above-mentioned breeds through which animal adaptation is tackled. These modalities are considered at the scale of a farm and at a collective scale. We then describe the various farmers' needs and expectations that can be included in the concept of adaptation. Specific attention is given to the notion of hardiness and to other technical and social considerations leading to a specific local breed choice and management. The several dimensions of adaptation illustrated in this paper invite to a higher consideration of farmers' practices and points of view in the management of local breed adaptation.

Keywords. Hardiness – Breeding practices – Adaptation – Local breeds.

L'adaptation des races locales n'est pas seulement une question biologique: illustration avec quatre races locales ovines méditerranéennes

Résumé. *Les races locales d'animaux domestiques ont été longtemps promues pour leur adaptation à des conditions spécifiques d'élevage impliquant une exposition du troupeau à différentes contraintes biophysiques. Bien que largement soulignée dans les travaux scientifiques récents, l'adaptation des races locales est peu renseignée pour de nombreuses races de Méditerranée, notamment pour les races ovines du nord de la Méditerranée. De plus, dans cette région soumise à de croissantes incertitudes de marché et contraintes biophysiques, il est nécessaire d'adopter une approche plus large de l'adaptation en considérant des ressources génétiques adaptées comme des ressources génétiques modelées par les pratiques humaines afin de contribuer à la résilience des systèmes d'élevage dans un contexte de changements globaux. Cet article se base sur des illustrations issues de deux études de cas en France, mobilisant quatre races locales ovines méditerranéennes. Nous identifions d'abord les modalités de gestion à travers lesquelles l'adaptation de ces races est abordée. Ces modalités sont considérées à l'échelle de l'élevage et à l'échelle collective. Nous décrivons ensuite les différents besoins et attentes des éleveurs qui peuvent être inclus dans le concept d'adaptation. Une attention spécifique est donnée à la notion de rusticité et à d'autres considérations techniques ou sociales qui amènent au choix ou la gestion spécifique d'une race locale. Les multiples dimensions de l'adaptation illustrées dans cet article invitent à une plus grande considération des points de vue et pratiques d'éleveurs dans la gestion de l'adaptation des races locales.*

Mots-clés. *Rusticité – Pratiques de sélection – Adaptation – Races locales.*

Introduction: Local breeds adaptation is an increasing stake in the Mediterranean area

Local breeds of domestic livestock have been promoted for long for their adaptation to specific farming conditions involving an exposure of the flock/herd to various biophysical constraints. Biophysical constraints of the above-mentioned farming conditions are usually related to feeding resources, climatic conditions, terrain or infectious pressure in outdoors conditions. For instance, in the Alps mountains, the Abondance cattle breed can be considered as adapted to high mountain pastures due to its low sensitivity to heat or due to its ability to ingest and use rough dry forages for dairy production (Verrier *et al*. 2005). In the Caribbean region, the resistance of the creole cattle breed to several diseases associated with ticks' infestation is often mentioned (e.g. Mandonnet *et al*., 2011). Trypanotolerance is also a highly studied trait among different local cattle breeds in west African region (e.g. Berthier *et al*., 2015).

Although largely underlined in recent research studies and FAO reports (Hoffman, 2013; FAO, 2015), adaptation of local breeds is few informed for several local breeds of the Mediterranean area, including for sheep breeds of the North Mediterranean shore. Moreover, in this region submitted to increasing market uncertainties and biophysical constraints (e.g., drought, vector-borne diseases), there is a need to adopt a broader approach of adaptation and consider adapted genetic resources as genetic resources shaped by human practices in order to participate in the resilience of livestock farming systems in a context of global changes. Physiological processes analysis (Mandonnet *et al*., 2011) and landscape genomics are examples of recent works involving broader approaches of animal adaptation (e.g., Vajana *et al*., 2018), but individual and collective practices applied by breeders to increase the resilience of their farming system through animal adaptation are still rarely tackled.

When it comes to local breed farming in field situations, how is adaptation tackled by farmers themselves? What are the several dimensions of this adaptation at play? Thanks to two case studies involving four local sheep breeds, the aim of this paper is to illustrate the several dimensions at play in local breeds adaptation, and show that both animals characteristics and humans perceptions and practices are involved in local breed adaptation.

I – Methods: Two case studies on the management of four French Mediterranean sheep breeds

This paper rests on illustrations taken from two case studies in France, involving four Mediterranean local sheep breeds whose characteristics are described in the Table 1.

Table 1. Description of case-studies

Case study (France)	Breeds	Production	Breed status (FAO)	Population data
Corsica island	Corsican	Dairy	Not a risk	17000 ewes registered in the breeding scheme in 2016 *(data OS Brebis Corse)*
South Eastern mainland	Raïole Caussenarde des Garrigues Rouge du Roussillon	Meat	Endangered Endangered Vulnerable	2000 ewes in 2010 1600 ewes, in 2010 4000 ewes, in 2010 *(Germain et al., 2011)*

The Corsican sheep breed is managed through a breeding scheme mainly focused on the milk production criterion. The three rare breeds of South Eastern mainland of France are under conservation and managed within the same breeders' association especially for management of breeding animals and oriented towards the production of animals for meat. More recently, a group of farmers started a collective initiative to process and market wool from the Raiole breed.

We use data from previous studies made around those breeds (Perucho *et al*, 2019; Nozieres-Petit and Lauvie, 2018; Perucho *et al*, 2020; Verdoux, 2018; Drevon, 2021). We first identify the modalities of management of the above-mentioned breeds through which animal adaptation is tackled. These modalities are considered either at farm or collective scale. We then describe the various farmers' needs and expectations that can be included in the concept of adaptation, emphasizing the case of the hardiness traits, and other technical and social considerations leading to specific breed choice and management.

II – Animals characteristics and human practices are both involved in local breeds' adaptation

1. When human practices are directly linked with animal characteristics: the example of adaptation managed by Corsican farmers through different breeding practices and several "traits of interest"

In Corsica, adaptation of the flock to biophysical constraints can be managed by farmers through the identification of specific animal characteristics and the choice of replacement or culling animals according to these characteristics, also called "traits of interest". These traits of interest and the breeding practices are presented in the Table 2. The notion of "hardiness", that can refer to various traits of interest depending on farmers' views, is the object of a specific section in Part III.1.

Table 2. Examples of management of adaptation to biophysical constraints through breeding practices in Corsica

Animal characteristics at play	Human practices at play
Sensitivity to mastitis and sensitivity to diseases Udder depth for grazing	Internal replacement and culling
Ability to cope with transhumance	Female culling and choice of specific rams' providers
Feeding behaviour	Internal replacement, female culling and choice of specific rams' providers
Sensitivity to cold and humidity	Internal replacement, female culling and choice of external replacement within subpopulations of Corsican ewes or Corsican breed

Adapted from Perucho *et al*., 2019.

Not all traits displayed in Table 2 are taken into account by each farmer. Differences between farmers are mainly explained by the farm location and consequently the characteristics of the climate, the grazing offer and the terrain, exposing the flock to different levels of constraints. These differences also have to do with the farmer's perception of the characteristics of the Corsican breed and the natural selection operated in daily conditions. For instance, ability to cope with transhumance can sometimes be considered by farmers as self-regulated through animal losses on summer mountain pastures. Traits considered as "granted" by the Corsican breed will not necessarily be taken into account in breeding practices applied on a Corsican purebred flock.

Table 2 also illustrates that breeding practices adopted by Corsican farmers to improve flock adaptation to biophysical constraints can vary according to the trait considered. For instance, the farmer's strategy will depend on its ability to identify a trait of interest (or its absence) on individuals: udder depth or good health can be easily observed on breeding female of the flock, but this is not the case for sensitivity to cold and humidity or feeding behaviour. The latter traits are more often assessed through the farming conditions under which the breeding animals to be purchased are raised. For example, rams' providers should be known for their feeding and grazing practices and external replacement should be chosen within specific sub-populations of the breed, raised in the harsh conditions of the centre of the island and never crossed with lowland genotypes or Sarda breed.

Finally, the participation or not to the breeding scheme of the Corsican sheep breed influences the choice of animal providers but also the farmer himself in its choice of breeding animals from the flock, as the breeding scheme of the Corsican sheep breed is mainly focused on milk production, at detriment of adaptive traits from the point of view of several farmers and breeders. In this respect, it had been shown that Corsican farmers participating to the breeding scheme of the Corsican sheep breed can combine standardised tools for the collective genetic improvement of a breed and individual selection on specific animal characteristics so that the flock is able to respond to the specific constraints of the farm.

2. When human practices play a part in the adaptation of the breed through a strong social dimension: example of a collective organisation's response to biological hazard

In the history of the Raïole sheep breed, the breed has faced a biological hazard that has threatened the whole small ruminant production in the area: a brucellosis episode in the middle of the 1980's (Drevon, 2021). When brucellosis reached a large transhumant flock (about a thousand animals for a total of about 1600 in the whole breed), and in contradiction with the legal requirements, farmers decided collectively not to slaughter the flock, which would have meant a risk of disappearing of the breed. On the advices of several research and technical agents, they tried an experimental vaccine. However, they consequently faced the lack of harmonisation between three departments' regulations: in one department, the vaccine was mandatory, in another department, it was forbidden, whereas in the third department, both options were possible. The farmers nevertheless performed transhumance with their vaccinated flocks in the department where it was forbidden. During a sanitary control, animals were tested positive and consequently 16 farmers were judged in front of the local court. They were judged guilty but were given no penalty as it was recognised that their aim was to preserve their flocks. As a consequence, the breed has been persevered thanks to this collective choice in the way to face the brucellosis episode (Drevon, 2021). This example illustrates how the breed can be a lever to respond a biological hazard, but rather in its social dimension than its biological one.

III – Adaptation for who? The definition and assessment of adaptation itself depends upon stakeholders' views

1. The case of the hardiness trait: a definition and assessment that is farmer-specific

As far as breeds' adaptation is concerned, hardiness is a key notion. Our study highlights that it has a definition which particularly depends upon the farmers' views. It can be difficult to objectify or decompose in elementary characteristics, as it refers to the set of abilities that a farmer expects from his animals under the specific constraints of the flock's living conditions. This trait is usually

depicted by Corsican farmers as the combination of several traits of interest related to the adaptation to biophysical constraints. Among the most cited one are the low sensitivity to diseases, the low sensitivity to climatic variations, the degree of rangeland exploitation in relation to milk production, the walking ability and the longevity of the ewes (Perucho *et al*., 2020).

Corsican farmers often assess hardiness of breeding animals through indirect indicators, that can be the characteristics of an animal, characteristics of a population or a breed, but also characteristics of a farm or a farmer. The indicators used to assess hardiness are farmer-specific and can refer to (i) specific hardy subpopulations of the Corsican sheep breed coming from the mountainous centre of the island (small size and specific horn conformation), (ii) low sensitivity to cold (black-coloured fleece) or/and (iii) the opposition between the Corsican breed, traditionally raised in pastoral systems, and the crosses of the Sarda breed, of bigger conformation and considered by farmers to be mostly found in the (less pastoral) farms of the coastal lowlands of the island. With this purpose, the choice of animal providers maintaining pastoral practices, displaying ancestral knowledge and a strong attachment to the standard of the Corsican sheep, or not participating to a breeding scheme highly focused on milk production, can be often considered as a guarantee for purchasing hardy breeding animals.

Likewise, the examples of East Southern mainland of France can illustrate how breeders associate or favour different traits of interest to define and assess the hardiness of their animals. Verdoux (2018) report the example of a Raïole farmer for whom hardiness mainly consists in the capacity to feed from different types of available resources (illustrating on oaks example), but as well for whom it is a breed well adapted to walking. A farmer rearing the Caussenarde des Garrigues breed mentioned a global approach of hardiness, without specifying a trait in particular but rather talking about compromise between hardiness and conformation: “it is not necessarily a breed very well conformed but it manages oneself well in our Garrigues lands” (Verdoux, 2018). More generally, this study shows that the appreciation of hardiness is relative because a breed considered hardy by some farmers may be considered less hardy by others (Verdoux *et al*., 2018). However, for the sheep farmers who settle down, hardiness is an important criterion for the choice of the breed. They evaluate this hardiness at the scale of the breed, very often by comparing it to one that they consider less hardy, either because they have raised it before, or because they refer to the systems of breeding in which the latter is used (Verdoux, 2018).

2. Local breed’s adaptation to farmer’s needs and expectations

The analysis of the traits motivating Corsican farmers in their choices of breeding animals indicated that adaptive traits considered in their decision-processes do not only concern adaptation to biophysical constraints but also adaptation to work management and to the farmer’s perception of his work. Indeed, ease of milking (through specific udder conformation) and behaviour with humans are traits of interest frequently mentioned by farmers and often considered in the choice of internal replacement, purchase of breeding animals and for the choice of culling animals. Likewise, the breed standard as a reflect of the farmer’s identity is a characteristic sought by farmers so that the flock is adapted to its owner’s perception of the farming activity.

In the East Southern mainland of France, the Raiole breed is managed under a specific collective organization supported by a strong network of farmers. This network provides mainly technical information and opportunities for the purchasing of breeding animals, but it can also support collective projects for marketing products or informal exchanges. For farmers beginning with sheep farming, the social aspects of its management, adapted to their expectations and needs at the beginning of their farming activity can be one of the reasons of their choice. The choice of the breed can also be in relation with the assistance of a “reference person” throughout the development of their activity. This person can for example be a retired farmer of the breed, assisting young farmers who are not from a farming background (Verdoux, 2018).

IV – Discussion and conclusion. Tackling local breeds' adaptation: a diversity of dimensions and levers at play

When dealing with local breeds adaptation, the risk of focusing only on animal characteristics risks to limit the question to a biological dimension while other dimensions of the local breeds are at play, like the social and technical dimensions.

The breeding practices performed by the farmers in order to improve the flock adaptation for biophysical constraints illustrate that several levels of organisation play a role in interrelation (practices at the farm scale and at the collective breed management scale). Farmers' perception and behaviour towards the collective management of the breed have been for example studied by Labatut *et al.* (2012) in local dairy sheep breeds of Western Pyrenees in France.

It is also important to consider the diversity of levers at play in the adaptation of local breeds: for example, the collective management is a lever for genetic selection but also to respond to biological hazards which influence the ability of a breed population to be maintained or not in its territory.

Finally, an adapted breed is a breed whose characteristics or attributes (Nozières-Petit and Lauvie, 2018) are meeting the farmers' needs and expectations. We illustrated for example that pursuing a "hardy" breeding animal does not have only to do with selecting objectified animal characteristics conferring adaptation to biophysical constraints. Results have been obtained in this sense by Vallerand (1988), Hubert *et al.* (2011), Tesniere *et al.* (2013) and Phocas *et al*. (2014). The multi-dimensional definition of hardiness is in this respect a challenge for its phenotyping (Friggens *et al*., 2017) and its subsequent indexation in official breeding programmes.

With this in mind, more studies are needed on how farmers assess the effects of their own practices to improve adaptation of their animals, and adjust these practices when needed. Studying further local breeds adaptation demands for interdisciplinary approaches to allow such a complementarity, as well as participative approaches to better take into account farmers points of view and practices.

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Effects of heat stress on welfare in Karagouniko sheep breed

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Abstract. The sustainability of sheep production in the Mediterranean basin faces considerable challenges in front of the ever-escalating effects of climate change, with animal welfare seriously compromised due to heat stress and the heat stress accompanied are the most severe effects. The Karagouniko sheep is a hardy local breed very well adapted in specific environments and low input farming systems. In this article an estimation of the effects of heat stress on the welfare of Karagouniko ewes is presented, utilizing the AWIN Welfare Assessment Protocol for Sheep®. The Karagouniko sheep flock, where the experiment took place, is managed semi-extensively at a semi-mountainous area in Thessaly, Greece. Severe and extreme severe heat stress conditions were recorded throughout the experimental period. Despite this, ewes' welfare indices remained in their entirety within desirable levels, highlighting the importance of local farming practices.

Keywords. Welfare – Sheep – Karagouniko breed – Heat Stress.

Les effets du stress thermique sur le bien-être dans la race ovine Karagouniko

Résumé. *La viabilité du secteur ovin dans le bassin méditerranéen est confrontée à des défis considérables face aux effets croissants du changement climatique. Le bien-être des animaux est en danger à cause du stress thermique et ses effets si graves. La race ovine Karagouniko est une race locale rustique très bien adaptée aux environnements spécifiques et dans des systèmes d'élevage à faibles intrants. Dans cet article on présente une évaluation préliminaire des effets du stress thermique sur le bien-être des brebis Karagouniko en utilisant le protocole de l'évaluation de bien-être des ovins, AWIN (Welfare Assessment Protocol for Sheep®). Le troupeau de la race ovine Karagouniko où l'expérimentation a eu lieu,est géré dans un système semi-extensif dans une zone semi-montagneuse en Thessalie, en Grèce. Des conditions du stress thermique sévères et extrêmement sévères ont été enregistrées tout au long de la période expérimentale. Malgré tout, les indicateurs de bien-être des brebis sont restés à des niveaux satisfaisants, soulignant l'importance des pratiques d'élevage locales.*

Mots-clés. *Bien-être animal – Brebis – Race ovine Karagouniko – Stress thermique.*

I – Introduction

The sustainability of sheep production in the Mediterranean faces considerable challenges before the ever-escalating effects of climate change. Given that the Mediterranean basin has been identified as a highly susceptive region to climate change and accompanying systemic failures as a result of it, severe constraints to sheep productive efficiency are already observed (IPCC, 2014). Sheep welfare is seriously compromised due to the variety of climatic stresses that are imposed to them, with heat stress being accompanied with the most severe, detrimental effects (Battini et.al, 2016; Al-Dawood, 2017; Karatzia *et al*., 2015; 2015; 2016; 2016; Sejian *et al*., 2017; Rivas *et al*., 2019; Silanikove, 2000).

Sheep breeding is considered one of the most dynamic sectors of the rural activity in Greece with around 8.5 million sheep raised in 83.8 thousand farms (data 2019, Hellenic Statistical Authority), making up for 14% of the total EU sheep population (Eurostat, 2020). This population is charac-

terized by a diversity of local breeds and local populations that co-exist with exotic breeds and various crossbreds raised in a variety of production environments. A major part of this population is managed in low input farming systems, capitalizing on the availability of natural pastures and the successful adaptation of the animals to their respective microclimates (Perucho *et al*., 2018; Hatziminaoglou, 2001; Ligda *et al*. 2009).

In the region of Thessaly in Central Greece, the Karagouniko is the main local sheep breed raised on semi-extensive lowland farms. The Karagouniko sheep, predominant in the region in 1985 (Georgoudis *et al*., 1995), shows decreasing trends and currently 4,500 ewes are under milk recording scheme, in a total estimated population of 50,000 heads (data 2019, EFABIS).

The Karagouniko sheep is highly appreciated by farmers for its milk production and ability to adapt in a variety of environments and low input farming systems (Perucho *et al*., 2019). Recent studies in the region, showed that some farmers of Thessaly decided to reintroduce Karagouniko breeding males in highly productive crossbred flocks (involving exotic breeds) aiming to improve the flock response to some constraints of the biophysical environments, such as the sensitivity to thermal stress (Perucho *et al*., 2019).

Although this trend is recent and observed on a limited number of farms, the future challenges associated with climate change in the Mediterranean area suggest that the use of local breeds to respond these challenges could increase in the future. In this context, there is increasing interest to study the response of the Karagouniko sheep managed in extensive or semi-extensive systems at different stressors that compromise animals' welfare.

The aim of the present study is to estimate the effects of heat stress on the welfare of Karagouniko sheep, taking into consideration local farming practices and climatic conditions.

II – Materials and methods

The study was carried out in a commercial dairy farm of Karagouniko sheep breed which was managed semi-extensively and was located in Avra-Kalambaka, Greece (39.714844, 21.683770) at an altitude of 220m. The flock consisted of 125 sheep, 117 of which were ewes. The animals grazed in natural and artificial pastures located in the greater area close to the farm. When necessary, supplemental nutrition of vetch, oats and corn was offered on farm. Welfare assessments, one per summer month (June-July-August), both at individual and group level were undertaken for all ewes at second lactation represented 10% of the flock. Assessments were conducted by the same researcher to ensure the validity of the data collected. All assessments were performed in accordance to the AWIN Welfare Assessment Protocol for Sheep® (2015). Ambient temperature and relevant humidity were recorded at 5-min intervals by digital sensors during grazing and on-farm (26.036 pairs of measurements) from May until September.

Thermal Heat Index was calculated according to Marai *et al.* (2007), by the following model:

T.H.I.= Environmental Temperature – (0.31-0.0031 * Relative Humidity)
* (Environmental Temperature-14.4),

Where: T.H.I. < 22.2 indicated absence of heat stress,

22.2 ≤ T.H.I. < 23.3 indicated moderate heat stress,

23.3 ≤ T.H.I. < 25.6 indicated severe heat stress, and

T.H.I. ≥ 25.6 indicated extreme severe heat stress

Individual Thermal Heat Index was calculated by substituting Environmental Temperature with Mean Body Temperature as it was estimated by the average temperature of the forehead, the wither, the rump, the udder, the flank and the chest, using an infrared thermometer.

Additionally, rectum temperature was recorded, along with respiratory rate and body condition score, after time was allowed for the animals to rest on farm upon the return of the flock from pasture.

Behavioural observations and measurements at animal and flock level were performed (shadow-seeking, lethargic behaviour etc.), in combination with the welfare assessment protocol for sheep AWIN® (2015) on first and second level (Individual and farm level)

Data collected were statistically analysed using SPSS® v.24, at a confidence level of a = 0.05.

III – Results and discussion

Heat Stress: Environmental Monthly Thermal Heat Index was calculated on June, July and August (EMTHI) and on the specific visit days of welfare assessment (VDTHI) when the flock was assessed (from the time animals left the farm for grazing until the time they returned) (Table 1). Mean Individual Thermal Heat Index (MITHI) was calculated on visit days (one/month), using the Individual Thermal Heat Index of the 12 ewes participating at the experiment (Table 1).

Table 1. Mean values of Thermal Heat Indexes (Environmental Monthly Thermal Heat Index-EMTHI, Visit Days Thermal Heat Index-VDTHI and Mean Individual Thermal Heat Index-MITHI)

Month	EMTHI (Mean ± SE)		VDTHI (Mean ± SE)	MITHI (Mean ± SE)
June	24.56 ± 0.055[a]	1st Visit (June)	24.06 ± 0.385[a]	28.76 ± 0.124[a]
July	26.00 ± 0.042[b]	2nd Visit (July)	23.55 ± 0.390[a]	26.86 ± 0.190[b]
August	24.66 ± 0.056[a]	3rd Visit (August)	27.06 ± 0.408[b]	29.13 ± 0.287[c]

Values within a column with different superscripts differ significantly at a ≤ 0.05.

Environmental Monthly Thermal Heat Index ranged between 24.56 and 26.00, indicating the prevalence of severe heat stress throughout the experimental period. A corresponding trend was recorded for Visit Day Thermal Heat Index, with 1st and 2nd visit index remaining within severe heat stress limits, while on the 3rd visit, VDTHI crossed over, increasing significantly (P≤0.05), indicating extreme severe heat stress conditions. In partial accordance to VDTHI, Mean Individual Thermal Heat Index reduced significantly (from 28.76 to 26.86, P≤0.05) at the second visit, before increasing significantly at the 3rd visit (from 26.86 to 29.13, P≤0.05) and approaching extreme severe heat stress levels.

Body Condition Score (BCS): This indicator was assessed while the ewes were restrained, by palpitation of the spine in the lumbar region, at the point after the last rib. The BCS classification was based on Morgan-Davies C. *et al*, 2007. Scores for all three visits can be seen on Table 2. Body Condition Score was evaluated as Good (>2.0, <4.0) with spine processes easily distinguished with light pressure, clear muscle, and fat cover in all ewes.

Table 2. Mean values of Body Condition Score and their classification

	BCS (Mean ± SE)	Maximum	Minimum	Classification
1st Visit (June)	3.20 ± 0.071	3.5	2.75	Good
2nd Visit (July)	3.35 ± 0.066	3.5	3	Good
3rd Visit (August)	3.2 ± 0.072	3.5	3	Good

The increase in BCS that was recorded at the 2nd visit, along with its reduction at the 3rd visit could be possibly attributed to the short-term rainy period that was observed during early July and resulted in rapid growth of vegetation in pastures, which allowed for the flock to have access to high quality and increased quantity grass.

Water availability: Animals had access to communal water troughs on pasture which utilized natural water sources, functioning, clean, unpolluted, and accessible. On a course of 7.4 kilometres on average, that sheep covered at each grazing, 2-3 communal water troughs were available (depending on the route they chose). On farm, water was available in 3 metal sheet troughs 5 meters long, where animals had access to fresh water upon their return from pasture and at nighttime. The troughs on farm were also fully functioning and cleaned regularly.

Fleece cleanliness: Most sheep were clean and dry with no signs of dirt or contamination on their fleece. It should be noted that the animals were sheared right before the onset of the experiment as is common practice in Greece, to help alleviate animals of the effects of heat stress and maintain feed conversion efficiency. 86.7% of sheep were scored as 0, and 13.3% of sheep were scored as one, which is attributed to the fact that during the second visit on the farm the weather was rainy for 5 days and animals got slightly damp during grazing.

Panting: This indicator was assessed before sheep were handled for other measurements and while they were in the pens. No animals with open panting were observed. On average, 33.3% exhibited normal respiration with an average of 27 ± 2.9 breaths per minute with the mouth closed, while 66.6% of the sheep showed signs of mild heat stress with a respiration rate of 34 ± 3.6 breaths per minute, where respiration occurred with the mouth closed and so, was not scored as panting.

Respiration Quality: After panting assessment and observation for hampered or audible breathing and persistent coughing and while ewes were handled, breathing was evaluated. No respiratory issues were detected in any animals. Breathing was normal with no obvious efforts to draw breath, no audible noise accompanying breathing, no coughing, and no nasal discharge.

Access to shade and shelter: While on pasture or during the grazing route followed by the flock daily, multiple sights with trees and shrubs functioning as shade/shelter were available, often in the vicinity of water troughs. The sheep utilized these sights by resting there when heat was severe or when it was raining heavily. The shrubs there also served as sources of feed.

Stocking Density: The indicator was assessed on farm, where adult ewes without lambs were estimated to have approximately 1.4 m^2 of pen area per animal at their disposal. Feeding throughs were located both in the pen and at the yard, to minimize overcrowding when supplementary feed was offered.

Hoof Overgrowth/ Lameness: All animals assessed showed no signs of hoof overgrowth. As the flock walked long distances twice daily for grazing, natural wear of the hoofs occurred, and no lameness issues were recorded (Score 0-Not lame). As the flock approached the farm after grazing, the movement of the ewes was assessed as smooth, with weight equally borne on all four feet with no shortening of stride. Some minor head nodding which is acceptable was evident, as animals were walking on uneven ground.

Body and Head Lesions/ Leg Injuries: No red skin patches, scabs, skin lesions, or wounds (current and healed) were observed at any area of the body (head and neck, ears, eyes, body) of the assessed sheep. At the first visit, a minor heat rash was recorded in two animals, at the flank area, due to the shearing that had been performed two days prior to the first evaluation. The rashes in both ewes had healed by the second visit and caused no distress or appetite decrease. Additionally, a complete absence of swellings, hairless patches, callus, lesions, or scabbed areas on the joints of the legs, which would indicate arthritis, injuries or trauma, or prolonged lying on hard surfaces were recorded.

Faecal Soiling: Very light soiling (Score 1), described as a small quantity of faecal matter in the wool around the anus was assessed in 66.6% of the ewes. Light soiling and dags (Score 2), specified as some soiling around the anus and dags (matted areas of faecal matter adhering to the wool) in this area only, was recorded in 33.3% of the animals. As the breed has a long semi-fat tail, that occasionally can even reach the ground, soiling can be observed often.

Mucosa Colour: The colour of the conjunctiva of the bottom eyelid of the ewes was inspected and evaluated as not anaemic in all animals. On average of the three visits, the 16.7% was classified by Score 0 (deep red mucosa), while the rest by Score1 (bright ted mucosa).

Ocular Discharge: Due to irritation caused by little twigs on gorse plants (*Pistacia lentiscus*), ocular discharge was observed in 2 animals at one visit (5.55%) and was treated by the farmer after consulting a veterinarian.

Mastitis and Udder Lesions: The indicators were recorded as the ewes were gently restrained in a standing posture and the udder was inspected from behind for colour and symmetry, palpated on both sides feeling for lumps, hardness and fibroids. No lesions to the udder or teats were found in any animals, as well as no mastitis or lesions were present. Udders in all animals were soft and piable at palpation, without any redness or hardness.

Fleece Quality: As previously mentioned, the flock was sheared two days prior to the first assessment and as a result fleece quality was not be evaluated. No bald patches or shed areas were found on any ewes.

Tail Length: The indicator was observed both in unhandled animals and verified in handled ewes. Karagouniko sheep have semi-fat long tails and common practice in commercial farms is to avoid docking lambs' tails. Undocked tails extended approximately below the hocks in all animals assessed.

Social Withdrawal/Stereotypy: The undisturbed flock was observed for 20 minutes, upon their return on farm from pasture. No single animals were clearly apart from the rest of the social group, standing at the back of a pen, standing or lying apart from main body of the flock and not engaged in any maintenance activity and unresponsive to activity occurring around them. Stereotypy assessment was also performed after the flock was left undisturbed for 20 minutes. Repetitive pacing or circling where the animal follows the same route back and forth or around the pen; repeatedly curving the head back over the shoulders and looking upwards; repeatedly pulling as well as biting or plucking the wool along the back of another ewe, were not observed. Surprisingly, a characteristic stillness behaviour (Budging) was observed. Budging was spontaneously manifested upon return from grazing, when sheep would hoard at the darkest area of the building and remained still and in immediate contact with each other. This behaviour could originate from a visceral reaction to avoid sunlight in order to achieve heat stress alleviation.

Excessive Itching: The undisturbed flock was observed for 20 minutes, upon their return on farm from pasture. No animals showed signs of excessive itching: repeated or prolonged rubbing or scratching, against pen or paddock fixtures or with the hooves. Ewes did not roll the head backwards over the shoulders attempting to scratch with the horns.

Quality Behaviour Assessment: Four observation points were selected in the pens with five minutes of observation per observation point. All ewes were alert (observant and vigilant), relaxed (at ease, free from anxiety, agitation or tension and they appeared to be unthreatened), content (satisfied and at peace, with their needs met), sociable (seeking and interacting with other sheep, appeared to be enjoying/taking comfort from their contact and chose to be part of a flock and not fully isolate themselves), calm (placid and sedate), bright (alert, lively and aware of environment) and assertive (displaying confidence or determination).

Familiar Human Approach Test: The farmer was asked to approach the sheep in the normal manner on foot, as if he was inspecting sheep. The purpose of this assessment was to gauge whether the farmer can feasibly approach his stock to carry out an inspection. Record the closest possible distance of approach before a flight response is elicited. No flight response was triggered (sheep remained motionless at human approach) and the ewes actively moved towards (sheep walked directly towards the farmer) and interacted (sniffing, nosing) with the farmer.

IV – Conclusions

Farms on semi-mountainous/mountainous areas are confronted with Heat Stress effects at an escalating intensity as semi-extensive management practices offer little protection to sheep from the adverse effects of climate change and microclimate both on farm and pasture is of integral importance for the protection of the flock's welfare. In spite of the challenges encountered on a daily basis, the production system applied in the semi-intensive farm studied, allowed for the management of sheep more as individuals rather than as a flock and for the daily adaptation of grazing schedule and duration by the farmer, according to the flock's needs. This fact provided sheep with the flexibility of adjusting their grazing and resting habits according to weather conditions and Heat Stress effects, thus protecting their welfare. In support of the above, Mean Individual Thermal Heat Index was significantly increased –and decreased– in accordance to Visit Day Thermal Heat Index, indicating that ewes have the ability to quickly adapt to the surrounding environmental conditions and de-escalate the effects of heat stress. The manifestation of budging behaviour on flock level upon return from grazing is a characteristic example of behavioural adaptation to environmental conditions, as an effort to achieve metabolic homeostasis, originating from a visceral reaction. This collective animal behaviour as a form of social reaction involving the coordinated action of the whole flock accentuates the capability of Karagouniko sheep to engage strategies that protect their welfare. Despite the prevalence of individual extreme severe heat stress, ewes' welfare indices remained in their entirety within desirable levels, highlighting the importance of local farming practices (such as shearing at the beginning of the summer and tail docking avoidance).

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Benefits from recent and on-going projects on adaptation and resilience in French dairy sheep and goats

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Abstract. In France, dairy sheep and goats have developed efficient breeding schemes, whose annual genetic gain ranges from 0.10 to 0.27 genetic standard deviation of the total merit index, according to the breeds. From 2015 to 2020, the 5 dairy sheep breeds and 2 main dairy goat breeds have shifted to full genomic programs, based on reference population constituted of AI progeny-tested males. Currently, the breeding goals are similar for almost all the selected breeds and may be *per se* qualified as balanced, since they include efficiency criteria (milk yield and content), resilience criteria (udder health, resistance to scrapie), and adaptation to mechanic milking in order to mitigate the workload of the farmer in the milking parlour (udder morphology). There are increasing expectations for improving sustainability, robustness and resilience while still increasing efficiency. These new objectives are emphasized by the different stakeholders: the farmers, the industry, but also the consumers, the citizens. Opportunities occur to cope with these requests: a larger efficiency of selection offered by genomic programs allowing to consider new traits to select, new technologies and methods to limit the phenotyping costs (eg. use of MIR spectra), awareness and consent of all stakeholders to bring new challenges at the agenda (climate change, growing resistance to antibiotics or anthelmintics). Various recent or on-going projects (eg. iSAGE, RUSTIC, ARDI, SMARTER) are addressing the topics of adaptation, sustainability, resilience in small ruminants. Through the French dairy sheep and goat illustration, we propose to explore the following ways, that are the core objectives of the on-going SMARTER project: breeding for new efficiency and resilience traits in a context of more agro-ecological systems and pursuit of self-sufficiency in the feeding systems; benefiting from international harmonization and cooperation; tackling the genotype x environment interactions; sharing the ideas and solutions across the wider range of stakeholders.

Keywords. Dairy sheep – Goat – Word – Adaptation – Resilience – Selection.

Enseignements de projets récents ou en cours sur l'adaptation et la résilience des brebis et chèvres laitières en France

Résumé. *En France, les brebis et chèvres laitières bénéficient de schémas de sélection efficaces, dont le progrès génétique annuel varie, selon la race, entre 0.10 et 0.27 écart-type génétique. De 2015 à 2020, les 5 races ovines laitières et les 2 races caprines en sélection ont basculé vers des schémas de sélection génomiques, basés sur des populations de référence constituées de mâles d'IA testés sur descendance. Actuellement, les objectifs de sélection, assez similaires d'une race à l'autre, peuvent être qualifiés d'équilibrés, car ils incluent des critères de production et d'efficience (quantité et richesse du lait), des critères de résilience (santé de la mamelle, résistance à la tremblante) et d'adaptation à la traite mécanique (morphologie de la mamelle). Des attentes, soutenues par l'ensemble des acteurs des filières, sont fortes pour améliorer la durabilité, la robustesse, la résilience tout en améliorant l'efficience des animaux. Des opportunités existent pour traiter ces demandes : plus grande efficacité de la sélection offerte par la génomique, nouvelles technologies ou méthodes, prise de conscience et consentement des acteurs pour mettre en avant ces nouveaux challenges (changement climatique, résistance aux antibiotiques et aux anthelminthiques). Plusieurs projets, récents ou en cours (ex. iSAGE, RUSTIC, ARDI, SMARTER), abordent les questions d'adaptation, de durabilité et de résilience en petits ruminants. Au travers de l'exemple des chèvres et brebis laitières françaises, nous proposons de baliser*

les thèmes suivants, qui sont au cœur du projet SMARTER: la sélection de nouveaux caractères d'efficience et de résilience dans une contexte d'intérêt croissant pour des systèmes plus agro-écologiques, recherchant plus d'autonomie alimentaire; l'intérêt de l'harmonisation et de la coopération internationale; les interactions génotypes x milieu ; la partage des idées et des solutions par un large réseau d'acteurs et d'utilisateurs de la génétique et de la production de petits ruminants.

Mots-clés. *Ovin lait – Chèvre – Adaptation – Résilience – Sélection.*

I – Dairy sheep and goats breeding programs in France

In 2020, the populations of dairy small ruminants in France reached 885,000 dairy goats and 1,660,000 dairy sheep (Idele, 2020). Two dairy goat breeds and 5 dairy sheep breeds are under selection and benefit from breeding schemes: Alpine and Saanen in goats; Lacaune, Corse, Basco-Béarnaise, Blond-Faced and Black-Faced Manech in sheep.

1. Breeds under selection and main features of the breeding programs of French dairy small ruminants

The Table 1 gives a summary of the main features of the breeds under selection. The population size of the breeds ranges from 80,000 ewes in Basco-Béarnaise to 1,130,000 ewes in Lacaune. The percentage of females involved in the breeding programs varies from 12% on the Black-Faced Manech to 30% in the Basco-Béarnaise breed. The number of new males put in AI each year depends on both the rate of AI and the size of the population in selection. These programs are efficient and allow an annual genetic gain comprised between 0.10 to 0.23 genetic standard deviation of the total merit index.

Table 1. Main features of the breeds under selection in France. G: dairy goats; S: dairy sheep

Breeds	Alpine (G)	Saanen (G)	Lacaune (S)	Corse (S)	Basco-Béarnaise (S)	Black-Faced Manech (S)	Blond-Faced Manech (S)
Population (thousands)	450	350	1,130	85	90	80	270
% in breeding program	27%	20%	20%	21%	30%	12%	28%
# new males in AI per year	50	40	445	25	44	26	146
%AI in breeding program	34%	34%	85%	36%	50%	45%	50%
Annual genetic gain (genetic std)	0.17	0.17	0.23	0.10	0.16	0.11	0.17

2. Implementation of genomic selection

Genomic selection (GS) has been gradually put in place over the last 5 years (Astruc *et al*., 2016, Carillier *et al*., 2013), starting in 2015 in Lacaune breed, then Manech and Basco-Béarnaise sheep breeds in 2017, the Alpine and Saanen goat breeds in 2018 and the Corse sheep breed in 2020. With GS, progeny test has been totally (in sheep breed) and partially (in goats) suppressed and young males with genomic proofs are used as sires since sexual maturity, allowing a decrease in generation interval. The genetic selection pressure is done using GEBVs at birth, with reliabilities (using the method to approximate reliabilities in single-step genomic evaluation proposed by Misztal *et al*., 2013) ranging from 0.40 to 0.70 according to the reference population size. Currently, the practical impact of GS has only been assessed in the Lacaune breed as the other breeds have just started. This impact has been estimated at a 30% higher genetic progress of the total merit index than traditional selection.

3. Current breeding goals

The breeding goals take into account production (fat & protein yields and contents) and functional (somatic cells, udder morphology) traits for all breeds but Corse where the selection criterion is still milk yield. In addition, resistance to scrapie has been integrated since the early 2000's in sheep.

The weight of the functional traits varies between 40 and 50%, except in Black-Faced Manech (15%) and of course in Corse breed (milk yield only). The similar weights for the different traits indicate that the desired and economic objectives are similar and therefore robust across species and breeds.

This shows that resilience traits (somatic cell count for resistance to mastitis, PrP genotypings for resistance to scrapie and udder morphology for both a healthier udder and a better ability for machine milking) are already being taken into account and almost all breeds are already heading toward balanced breeding goals.

II – A strong effort of R&D to meet the needs of more balanced breeding goals

The main demand from the stakeholders, and mostly the breeders, is to improve the resilience and the ability of adaptation of their animals. The resilience is intended as the ability of the animals, to undergo minimal perturbation from their performance trajectory and to get a fast recovery when submitted to an environmental challenge (climatic, disease, nutritional, etc). The adaptation is intended as the ability of the animals to live, breed and perform in their pedo-climatic environment and traditional system of production.

The need to improve efficiency also exists, even though it is maybe less pressing, in dairy sheep and goats than resilience. Efficiency consists in managing an optimal input/output balance. In turn, this means having good dairy, growing, reproduction and health performances, without excessive feed intake (feed efficiency) and without producing excessive greenhouse gases. This paper only focuses on resilience and adaptation.

Farmers, breeding organisations and related stakeholders are increasingly aware of the climatic change with its consequences on temperature and pastures and forages production and availability and of the more frequent health challenges (blue tongue, ticks, gastrointestinal parasites). They search animals able to tackle the challenges and manage the trade-off between efficiency of production and resilience, including reproduction and health and body reserves dynamics. In addition, the demand from the society of more agro-ecological agricultural system requires more resilient animals and production systems.

Besides the interest for improving adaptation and resilience, implementing more balanced breeding goals should result, in the long term, in a better management of genetic diversity. Indeed, selecting animals with a large spectrum of resilience-related abilities (in addition to efficiency-related abilities) will allow to maintain a large variation of alleles and haplotypes for a better capacity of adaptation to any possible environmental or external challenge.

Consequently, a huge effort has already been done and is currently being done to meet these needs with various R&D projects, among them SMARTER (Moreno *et al*., 2020, SMARTER web site, 2018), iSAGE (ISAGE website, 2016), RUSTIC (Astruc *et al*., 2021), ARDI (ARDI website, 2017;Granado-Tajado *et al*., 2019), PARALUT.

III – Actual and expected benefits from recent and on-going project on adaptation and resilience

The following sections give some examples of the issues that have been investigated with emphasis on some main results.

1. Adaptation to climatic change

The adaptation to climatic change has been studied in the iSAGE project in dairy sheep and goats from different countries (Carabaño *et al.*, 2020). The main French results illustrates that there is a genetic variation regarding the animal response on milk yield production across a range of temperature. Moreover, the genetic merit of an animal is not the same depending on the temperature and each animal has his own pattern of behavior. For milk yield, the ranking of the animals at low temperatures is not the same as the one for higher temperature. Therefore, it is possible and profitable to select animals better adapted to higher temperature.

2. Genotype x Environment interactions

A recurrent question from the breeders and their organizations is whether their selected animals and breeding goals are well adapted to all the systems in which the animals are raised. Some interesting answers were obtained in the iSAGE project (Buisson *et al.*, 2020, Larroque *et al.,* 2018). For example, in the Lacaune breed, if we split the population in clusters representing a relevant variety of systems which might possibly display genotype by environment interactions, we observe that (i) the heritability of the traits is similar across the systems, suggesting that there is no (or very small) scale effect (Figure 1); (ii) the high correlations between systems (with some exception for somatic cells) indicates that there are few re-ranking of animals across systems (Figure 2).

Therefore, we can conclude that selection is well adapted to the range of environments where the breeds are raised. This means that the best males whose breeding value has been estimated using information across a large and representative panel of flocks/herds (reference population or sufficient numbers of daughters in sufficient numbers of flock/herds) will also be the best across all the flocks/herds of the population.

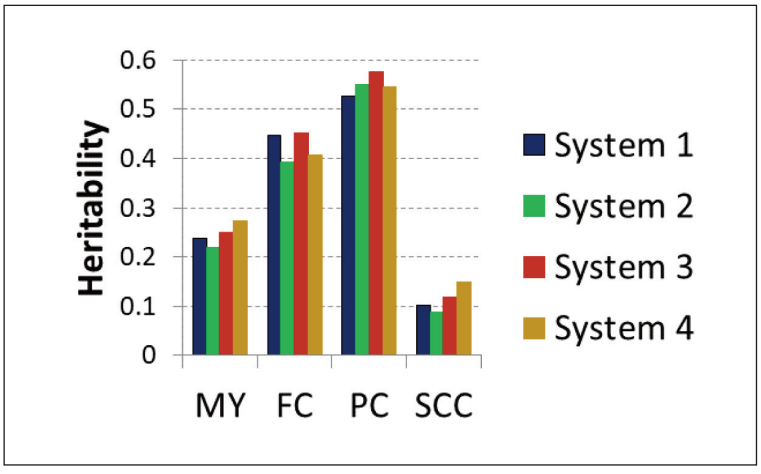

Fig. 1. Heritability of milk yield (MY), fat content (FC), protein content (PC) and somatic cells (SCC) across clusters of flocks representing the different production systems in Lacaune breed.

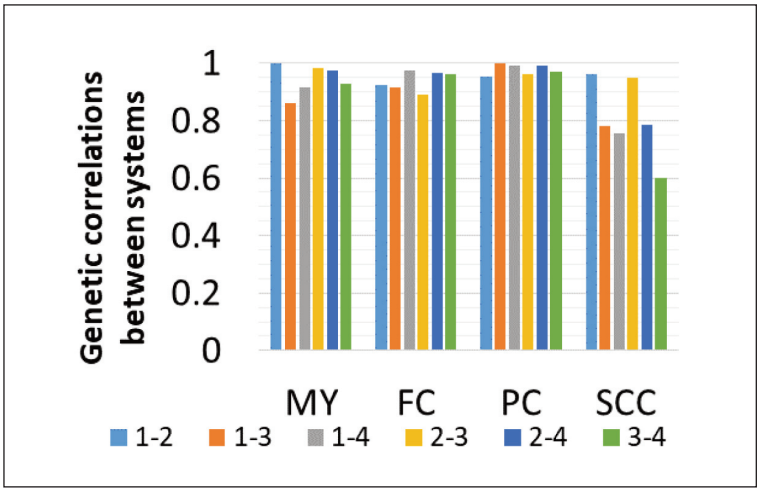

Fig. 2. Genetic correlations between clusters for milk yield (MY), fat content (FC), protein content (PC) and somatic cells (SCC) in Lacaune breed.

3. Functional longevity

Functional longevity is a good synthetic candidate trait to express resilience, because it incorporates different functional abilities for avoiding involuntary culling. Work based on the methods and tools developed in French dairy cattle shows that in both sheep and goats, functional longevity is positively correlated with udder health and morphology, fertility and persistency. Longevity based on life productive length, thus requiring data already collected through performance recording) should cope with various culling causes that cannot be easily and comprehensively recorded per se (Palhière *et al*., 2018, Buisson *et al*., 2020).

4. The SMARTER project and resilience-related traits

The Horizon 2020 SMARTER project (2018-2022) specifically deals with breeding for efficiency and resilience traits in small ruminants (Moreno-Romieux *et al*., 2020). The overall aim is to improve efficiency (higher feed efficiency, mitigation of greenhouse gases, optimization of dynamics of body reserve) while improving resilience, that means while managing the trade-off between both abilities.

In France, besides precise phenotyping in experimental farms, various measures are being carried out in a network of 30 commercial dairy farms. The phenotypes collected in the commercial farms are reproduction, longevity, culling causes, resistance to gastro-intestinal parasites, health scoring, medium infra-red (MIR) spectra as proxy for biological traits, metabolites to relate with health and body reserves. We must emphasize the great promise of MIR spectra, in dairy species for which samples of milk are regularly taken through the milk recording designs, to assess easily hard-to-measure traits.

This mix of academic (cutting-edge novel traits) and non-academic resources (easy-to-measure proxy for the latter novel traits) should result in practical recommendations for on-farm selection on resilience (and efficiency) traits in the future. The resilience traits studied in SMARTER are disease traits, behavioural traits, foetus and lamb/kid survival traits, longevity traits.

5. Resistance to gastrointestinal parasites

Resistance to gastrointestinal parasites is of increasing interest, especially in the Atlantic mild and humid area, at least for 2 reasons: because of growing evidence of anthelmintics resistance, and the negative impacts of anthelmintics molecules on the entomofauna of the soil in the pastures.

A design of controlled infections was conceived for rams gathered in station and has been used in the Pyrenean breeds for a decade (Jacqui *et al*., 2015). Faecal egg counts of nematodes are a proxy for resistance, with a large variability across rams (Figure 3). This trait is moderately heritable (Aguerre *et al*., 2018, Astruc *et al.,* 2017). Breeding values are yearly predicted and used in the breeding program. Breeding values of males are worth and useful, as proved by an experiment that showed that offspring from the 50% top sires (the more resistant) excrete on average half as many parasites eggs as those from 50% bottom sires (the more susceptible) (Aguerre *et al*., 2018).

Selection is therefore an efficient way to increase resistance to nematodes challenge in sheep, with a strategy based, (i) in the short term, on using resistant rams in flocks where there is presence of parasites resistant to treatment; (ii) in the medium term, on including resistance in the Total Merit Index. A similar approach is being tested in goats.

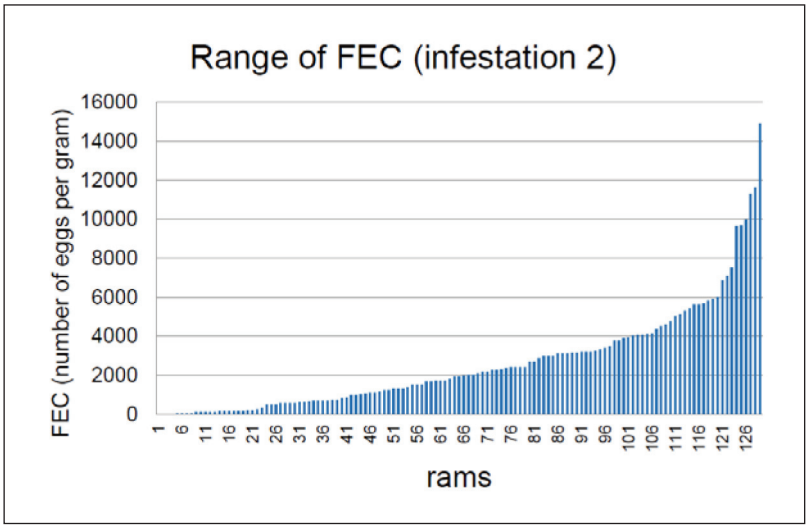

Fig. 3. Faecal Egg Count (FEC) distribution for young Blond-Faced Manech rams in a control challenge of infestation by Haemonchus contortus in 2014 (source Astruc *et al*., 2017).

6. Benefits from international cooperation

All the results presented in this paper, and the efficiency of the approaches leading to such results and to their concrete application in the breeding industry, lay on across-country cooperation. Regarding the research step, the different novel traits and novel approaches benefit from international projects with different teams working jointly on similar topics, exchanging their views, and permitting to build more robust “meta-results”. Then, regarding the application, small ruminant populations have a limited size and within country reference population are often small; consequently, as resilience and adaptation traits are hard-to-measure traits, pooling together data might be a prerequisite for success stories.

Consequently, it is beneficial to increase international cooperation, especially by proposing harmonized recommendations for recording resilience related traits, but also by assessing and promoting pooling of data to implement across country evaluations. Such an initiative of international cooperation is at the heart of some major projects such as SMARTER or ARDI. In the case of the SMARTER project, one of the purpose is to create an initiative of across-country evaluation in small ruminants. In the case of the ARDI project (Granado-Tajado *et al*., 2019), the goal is to go further and to implement a joint across-border selection program and a nutshell of an across-country breeding society.

IV – Conclusion

In French dairy small ruminants, breeders are increasingly addressing the issue of selecting more adapted and more resilient sheep and goats. Global warming, new health challenges, demand of the society for more agro-ecological and sustainable systems are strong drivers and incentives for this impetus. Novel adaptation and resilience-related traits have been / are under study, thanks to various projects. Some of them might rapidly be / are already included in selection criteria. Building more balanced breeding goals should benefit from more efficient genomic selection and also from international cooperation. This puts emphasis on the importance of joining research and development, and academics' and stakeholders' input.

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Documenting animal genetic resources in the Mediterranean: interaction and cooperation in the region

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Abstract. This study aims to present the status of animal genetic resources documentation in the Mediterranean region through specific country examples. For this purpose, data from six countries (France, Italy, Greece, Cyprus, Morocco and Tunisia) were exported from the Domestic Animal Diversity Information System (DAD-IS) and analyzed. The key figures refer to the number of breeds registered, breeds per risk status, population trends, degree of data completeness, etc. According to the analyzed data, the rate of completeness of population figures varied between 20% to 100%. The SDG 2.5.2 indicator in the countries was widely diverse. In addition, complementary data were collected through a questionnaire to understand the organizational structure and the relevant policies in each country. Previous work carried out in the frame of the European Regional Focal Point on farm animal genetic resources (ERFP) has been used and extended to Mediterranean countries not previously included in that survey. Means to stimulate data recording and promote the use of the DAD-IS system, as well as enhance the communication and interaction are also discussed, aiming to increase data availability and improve data flow between institutional, national, regional and international databases. This ongoing work reflects the primary aims and activities of the ERFP Working Group (WG) on Documentation and Information and the European Federation for Animal Science (EAAP) Mediterranean WG.

Keywords. DAD-IS – Animal Genetic Resources – Documentation – Conservation.

Documenter les ressources zoogénétiques en Méditerranée: interaction et coopération dans la région

Résumé. *Cette étude présente l'état de la documentation des ressources zoogénétiques dans la région méditerranéenne au travers d'exemples choisis dans différents pays. Les données de six pays (France, Italie, Grèce, Chypre, Maroc et Tunisie) ont été analysées à partir du système d'information sur la diversité des animaux domestiques (DAD-IS). Les chiffres clés concernent le nombre de races enregistrées, leur statut de risque, les tendances de la population, le degré d'exhaustivité des données, etc. Selon les données analysées, le taux d'exhaustivité des chiffres de population variait entre 20% et 100%. L'indicateur ODD 2.5.2 dans les pays était très diversifié. En outre, des données complémentaires ont été collectées au moyen d'un questionnaire pour comprendre la structure organisationnelle et les politiques pertinentes dans chaque pays. Les travaux antérieurs réalisés dans le cadre du point focal régional européen sur les ressources zoogénétiques (ERFP) ont été étendus aux pays méditerranéens non inclus auparavant dans cette enquête. Les moyens de stimuler l'enregistrement des données et de promouvoir l'utilisation du système DAD-IS, ainsi que d'améliorer la communication et l'interaction sont également examinés. L'objectif étant d'accroître la disponibilité des données et d'améliorer le flux entre les bases de données institutionnelles, nationales, régionales et internationales. Ce travail reflète les principaux objectifs et activités du Groupe de travail Documentation et Information de l'ERFP et du Groupe de Travail Méditerranée de l'EAAP.*

Mots-clés. *DAD-IS – Ressources Génétiques des Animaux – Documentation – Information.*

I – Introduction

The Mediterranean region is one of the world's richest in terms of livestock breed diversity, profiting from its proximity to the Middle East, the site of their original domestication. The region is characterized by mountain chains and sea straits where diverse breeds linked to the territory are raised in diverse production systems. This mosaic, in conjunction with the various transformation and marketing channels available, leads to a wide variety of products that reflect the natural and typical image of the region. This richness is a natural resource that can be used to ensure the sustainability of the farming systems and livelihoods in the rural areas. This richness can be also used to respond to new challenges mainly due to climate change (Boyazoglu, 2002; Boyazoglu & Morand–Fehr, 2001; Rancourt *et al.*, 2006; Hadjipavlou *et al.*, 2021).

In this context, the efficient management of animal genetic resources (AnGR) remains a challenging task that requires deep knowledge of the populations, as well as sufficient monitoring systems. Efficient management ensures that actions and targeted measures are taken early enough to prevent irreversible losses of genetic variability and enables the development of appropriate strategies for the sustainable use of livestock genetic resources.

Many local breeds that are not currently highly valued in the global commercial livestock production, have characteristics that make them potentially valuable in the growing market of niche products or in the provision of public goods, including ecosystem and cultural services (FAO, 2014a; Ligda and Casabianca, 2014). There is a need to benefit more from the advantageous characteristics of locally adapted breeds, particularly in line with challenges associated with climate change and the ongoing need for livestock that are suitable for use by small-scale producers and in low-input production systems. Characterization is expected to provide information on present and potential uses of livestock genetic resources that can be used to make decisions concerning their conservation and management. However, there are still knowledge gaps on the breed characteristics, underlying the need to improve the characterization of breeds (FAO, 2015; Hoffman, 2010; Tixier-Boichard, 2014).

Conservation actions are set up, based partly on the risk status of a breed, usually assessed by population data (population size and rate of change of population size), while genetic data and demographic parameters (such as level of crossbreeding, geographical concentration) can also be taken into account. Moreover, socio-economic and cultural aspects are also considered as important factors of the sustainability of local breeds (Gandini *et al.*, 2004). Multicriteria approaches have been developed in some European countries that take into account the diverse factors that impact the future of genetic resources (Verrier *et al.*, 2015)

The risk status of farm animal breeds is monitored at country level. Relevant information is gathered through characterization, surveying, and monitoring activities by breeders and other actors. Different information systems exist in the countries including databases of herd books and other specific AnGR-related databases. Data for monitoring the status and trends of AnGR globally are drawn from the Domestic Animal Diversity Information System developed by FAO (DAD-IS; http://www.fao.org/dad-is/en/). DAD-IS is the front-end of a global network of information systems developed and maintained by FAO. This Global Databank enables National Coordinators to enter breed-specific data, required to estimate risk status trends reports. Based on these data and additional information from Country Reports, FAO publishes the State of the World Reports (FAO, 2015). In the European region, the European Farm Animal Biodiversity Information System (EFABIS; http://www.fao.org/dad-is/regional-national-nodes/efabis/en/) operates as the regional node for the exchange of national data on animal genetic resources, provided by the European National Coordinators. Countries have the possibility to set up their own national information systems within EFABIS (national node).

The continuous efforts to update DAD-IS and promote the use of the Information System by FAO and European Regional Focal Point (ERFP), for the European region, have resulted to an increase

of data recorded, however the level of completeness of the system varies across countries (FAO, 2015; FAO, 2018). In general, the fields related with the demographic parameters are the most complete and updated regularly, but there is still room for improvement, while more gaps are observed in the data fields concerning cryo-conservation, and characterization of breeds. The identified gaps, either related with the monitoring of population data, regular recording and flow of data or with the breed characterization and documentation, require the enhanced cooperation between researchers, breeders and public administration.

The importance of livestock breeds diversity in the Mediterranean region and their historical evolution, leads to the need to assess the status and trends of livestock diversity in this geographical area that links two regions (Europe and Africa) as a whole, contributing to the enhanced cooperation in the region. This is a preliminary study that aims to present the status of AnGR documentation in the Mediterranean region, by analysing specific country datasets from DAD-IS and to provide insights to the current picture. The work aims to promote the improvement of DAD-IS data completeness and quality and its use for better monitoring and management of AnGR. The discussion considers also the links between recorded data and the actual situation, the activities carried out and their effect on the status of local farm animal genetic resources. The work was initiated through the activities of the ERFP WG Documentation and Information and the EAAP Mediterranean WG aiming to stimulate interaction and cooperation in the Mediterranean region in aspects related with the documentation of AnGR.

II – Material and methods

For this study, the cases of France, Italy, Greece, Cyprus, Morocco and Tunisia were examined. The work was based on the data recorded in the DAD-IS (http://www.fao.org/dad-is/en), the global Information System of FAO that is used for monitoring the status and trends of AnGR. The data on breed population sizes and conservation programmes are used to monitor Indicators 2.5.1 and 2.5.2 of the Sustainable Development Goals (SDG), according to the following definitions (FAO, 2018).

SDG indicator 2.5.1: Number of plant and animal genetic resources for food and agriculture secured in either medium- or long-term conservation facilities;

SDG indicator 2.5.2: Proportion of local breeds, classified as being at risk, not-at risk or unknown level of risk of extinction.

The following data of the six countries were extracted from DAD-IS on 05.11.2020.

i) Population data of registered breeds for all the years included in the database. Each year in the database included breed population figures, number of herds, information on Artificial Insemination (AI) use and *in situ* conservation programs, as well as the population trend.
ii) Data concerning the storage of animal genetic resources secured in conservation facilities (data used for SDG indicator 2.5.1).

IBM SPSS Statistics package version 25 (IBM SPSS, 2017) was used to produce the statistical figures and tables. Microsoft Access version 2019 (MS Access, 2019) was used to produce new tables by merging extracted tables, linking information on risk status and conservation measures.

The analysis provided summary statistics results on the number of breeds registered per species at country level and as a total, the number of updates (per year, species, country), breed distribution per risk status, population trends, degree of data completeness, and *in situ* conservation programs per risk status. Risk status per breed per country for all the years of data in the database was estimated based on the recorded population data.

In addition, complementary data were collected through a questionnaire, developed previously (2016) and sent by ERFP (WG Documentation and Information) to the National Coordinators, with the aim

to understand the organizational structure in each country. The questionnaire inclincludes information on the the following: criteria and methodology used to estimate endangerment status, bodies involved in the process (ERFP, 2017). Furthermore, new tools that could be implemented in the system providing an overall picture of the socio-economic environment of the breeds are discussed.

III – Results and discussion

The number of breeds registered per species in the six countries reflects the wide diversity of sheep breeds (175 breeds with population data) in the region, followed by cattle (108 breeds), horses (102 breeds) and goats (75 breeds). The countries have differential contributions to this regional diversity, as shown in Table 1. The variation is mainly due to the country size and importance of the relevant sectors, but it also gives indications on the historical role of Breed Societies and evolution of herd books in the countries. It might also reveal some differentiation between countries concerning breed recognition strategies and relevant interest from breeders.

Table 1. Number of breeds with population data in the countries

	Cyprus	France	Greece	Italy	Morocco	Tunisia	Total
Buffalo			1	1			2
Cattle	2	46	11	35	11	3	108
Sheep	6	61	23	71	8	6	175
Goats	5	17	2	45	5	1	75
Horses	2	55	7	30	1	7	102
Ass	1	7		8			16
Pigs		36	1	12			49
Rabbit	1	18		46	1		66
Chicken	2	51		18	1	3	75
Goose		7		2			9
Duck	2	6		2			10
Turkey	1	3		4	1		9

Figure 1 depicts the population data updates per year since 2000, provides a clear picture of the fluctuation across the years. In general, the number of updates is less than what would be expected based on the total number of breeds registered. This wide variation indicates the possible links of the data update frequency with other events (i.e., the process of preparation of the FAO State of the World Reports, regional Workshops, etc.) that may generate attention on this process temporarily, which is not maintained afterwards at a regular basis.

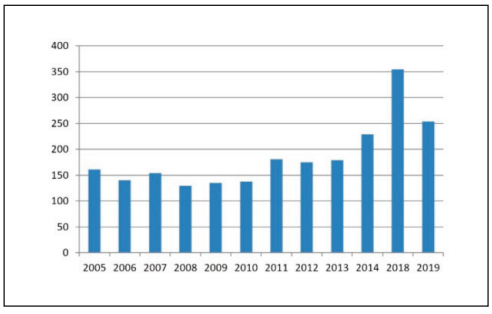

Fig. 1. Number of updates per year in all six countries.

There is variation between the countries, on the percentage of data completeness across breeds that is estimated having as year of reference the year of last update; this ranges from around 20% in Cyprus and Tunisia to 100% in Italy (Figure 2).

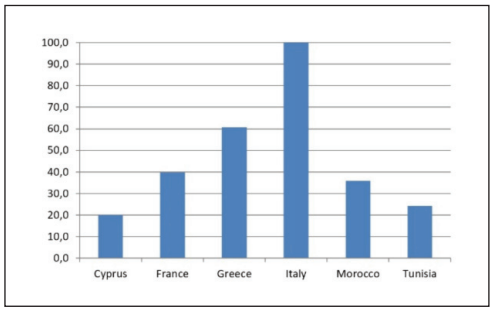

Fig. 2. Percentage of data completeness in the six countries.

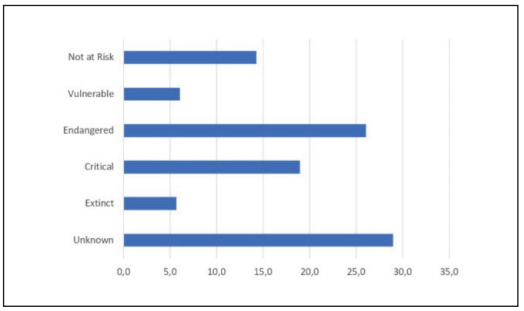

Fig. 3. Distribution of breeds per risk status category.

Examining the distribution of breeds per risk status category, only 14% are in the non-risk category, while 29% of the recorded breeds are still under unknown status (Figure 3). This underlines the need to continue the efforts to improve reporting on AnGR. However, it is important to note that for the 84% of the breeds under the three risk categories (critical, endangered, and vulnerable), *in situ* conservation actions are implemented (Table 2).

Table 2. Number of breeds under *in situ* conservation measures per risk status category

	No response	No	Yes
Critical	18	2	110
Critical maintained	1		19
Cryo conserved only	1		
Endangered	12	18	136
Vulnerable	3	8	37
Endangered maintained	2	3	35
Not at risk	7	25	81
Unknown	206	16	7

The SDG 2.5.1. indicator provides an overview of the local breeds secured in GeneBanks for long term conservation. From the recorded data on DAD-IS, it is shown that for 62% of the breeds, no information is recorded, while 30% of the breeds has no material stored in a GeneBank (Figure 4). Looking at the information at country level, one can make the hypothesis that this picture may deviate from the actual situation of the *ex situ* conservation activities in the countries, but it may also reflect the reluctance of countries to store such information on DAD-IS. This can be explained by several reasons, such as gaps of cooperation within/between institutes having GeneBank facilities and collections, lack of coordination and still, to some extent, lack of awareness on these indicators.

The SDG 2.5.2. indicator is a complex indicator which is difficult to interpret and utilize when lacking information. Considering that in some countries still a high number of breeds is under unknown status, which has a direct impact on the estimation of the SDG 2.5.2 indicator, we do not include these breeds within the estimated figure. The percentage of local breeds at risk within local breeds with known breed status, ranges from 10% to 90%, however this should not be examined as a static

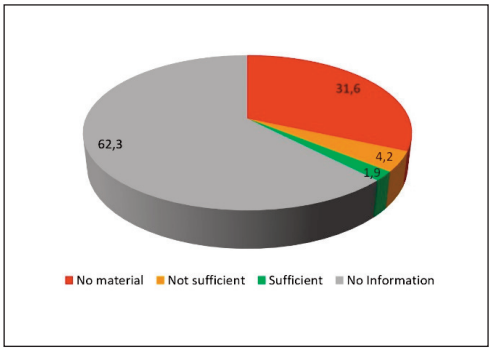

Fig. 4. SDG 2.5.1 indicator in the six countries of the Mediterranean region.

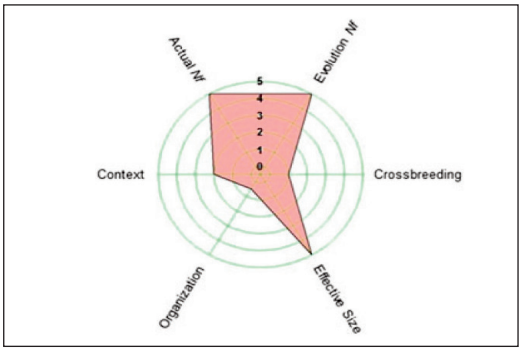

Fig. 5. Example of the multicriteria approach: Radar chart for Boulonnais horse breed (France), from Verrier *et al*. (2015).

number, but through its evolution in time. For this purpose, reliable data and frequent updates are necessary. The SDG 2.5.2 indicator in the countries examined is widely diverse, potentially indicating the extent to which DAD-IS was used for breed population data monitoring in each country.

From the information collected through the ERFP WG questionnaire, the Ministries of Agriculture (Rural Development and /or Environment, according to the country) have the coordination of the monitoring and documentation in all countries. Different roles and responsibilities are given to the regional departments according to the country's administrative organization. The policies and measures in the European countries of the Mediterranean region follow the relevant EU regulations, and specific measures are implemented through the Rural Development Plans (Ligda and Zjalic, 2011; FAO, 2015). Risk status is estimated by demographic criteria, while additional criteria following multicriteria approaches, are taken into account in some countries (ERFP, 2017); an example of the multicriteria approach is presented in Figure 5, from Verrier *et al*. (2015).

Relevant policies in Tunisia and Morocco, are under the responsibility of the Ministry of Agriculture and follow the FAO Global Strategy. National Focal Points (NFPs) are established in all countries. The FAO Sub-Regional Office for North Africa established in 1996 provides support to the five Maghreb countries: Algeria, Libya, Morocco, Mauritania and Tunisia, in particular through the provision of advice on general policies and the strengthening of institutional capacities and human resources. The need to develop joint projects, organize training workshops for farmers; improving collaboration in ex situ conservation by capitalizing on work already done; strengthening labelling measures; improve monitoring of AnGR; and creating a regional GeneBank were underlined by the participants of the Regional FAO Workshop in Rabat (FAO, 2014b).

Breeder associations participate in the management of AnGR, while Research and Technical Institutes are involved at a different level. The impact and role of the various stakeholders depends on the set structure in each country (e.g. Existence of National Committee for the management of AnGR). Several studies have emphasized the role of diverse stakeholder participation, including livestock keepers and breeders, in the management of AnGR (Lauvie *et al*., 2011; Leroy *et al*, 2017). Stakeholder participation refers to taking part in policy- level activities, but also in specific animal-level activities. One of the main findings of the study of Leroy *et al*. (2017) on the role of stakeholders in the management of AnGR was that the involvement of a particular stakeholder group was highly depended on the historical background and ideas behind the development policies and donor involvement.

In respect to the discussion on the improvement of DAD-IS utilisation, the outcomes of ERFP WG Documentation & Information on the approach aiming to elucidate the additional factors that shape the general environment (physical and socio-economic environment) might be of interest for the

whole region. Such information could be specifically of interest for breeds that are just above the demographic thresholds and could prove very informative to National Coordinators, policy makers, and regional administration, as it can provide straightforward overview visualization of a breed's status at different dimensions (socio-economic and cultural aspects). Other stakeholders as Breeder Associations or scientists can be also interested in this kind of information. The descriptors proposed refer to breed viability (market recognition, breed profitability, continuity of activity, subsidies dependency), existence of breeder organization and assessment of breeding / conservation program, Genebank status, Cooperation level, and Cultural value (ERFP, 2017).

IV – Conclusions

In general, this first analysis shows the richness of information provided by DAD-IS, which could be utilized by various users according to their specific interests and needs. Furthermore, a wide variation in updating DAD-IS is observed, between the years as well as between countries, but also within species and breeds within a country. The variation within a country reflects the changes in policies and priorities in the country, and the differences in the level of organization in each sector (e.g., the development level of Breeders' Societies etc.). The wide variation between countries corresponds to the differences in the policies, priorities and capacities between countries. The comparison between countries is only meaningful for identifying the organizational and other relevant structures that provide a positive environment for the efficient management of AnGR and data documentation, taking into consideration the specific situation in each country or region.

The presented figures show that there are still gaps in AnGR documentation. The first category of gaps relates to the lack of sufficient structure(s) for population monitoring and data flow organization, and the second one with knowledge gaps on the breed characterization. The two types of gaps require different approaches. All cases have a common need to raise awareness on the importance of updating the relevant fields and to establish links within the country (breeder associations, Institutes, etc.) that will ensure that all possible information is included. Lack of data or inaccurate data lead to imprecise interpretations of the global (and national) reports and indicators and therefore these cannot be used for developing relevant recommendations or action plans, or when these are used, this should be done with caution. Effective management of AnGR requires efficient monitoring that will lead to implementing the objectives of sustainable breeding programs and will ensure the conservation of AnGR for a viable future.

Having this in mind, means to stimulate data recording that will permit the efficient use of the DAD-IS system are discussed, such as developing specific tools to analyze groups of breeds of specific interest for certain areas. These analysis tools will potentially improve data collection strengthening of local capacities. Enhancing the communication and interaction between various stakeholders working in the field will increase data availability and improve data flow from institutional to national, to regional and international databases. In this context, the work developed by the ERFP WG Documentation and Information and the current activities aiming to enhance the exchange with National Coordinators from the countries of North Africa, will contribute to defining the existing drawbacks especially on aspects related with the necessary organizational structures to facilitate the involvement of livestock keepers and breeders. By identifying the weak points at country level and establishing a network, adapted to each country needs, an efficient data flow process will be facilitated that will improve the quality, accuracy and thus the use of the Information System. The gaps on breed characterization can be overcome through better and coordinated communication between researchers, public authorities, and breeder associations.

Would the establishment of a sub-regional focal point for the Maghreb countries help in this direction? The positive experience from the European Regional Focal point indicates that this could be a potential route to follow. The experience cannot be copied, but it would need to be designed

and adapted to the political, social and economic environment of the countries. Above all, networking and building stronger links across the two sides of the Mediterranean region is crucial. Joint regional activities would also be very efficient tools in this effort, not limited to but also including improved research cooperation and exchange programs that would capitalize on the positive experience and results of the ARIMNET and ARIMNET2 ERANET projects and the relevant current and future PRIMA Calls.

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Camel herd management under pastoral system in southern of Tunisia

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Abstract. Camels play an important role in the life of southern Tunisia population with 90% of camel flocks raised in this region. The aim of this study is to describe husbandry and breeding practices, herd structure, traditional veterinary practices and animal production parameters for camels raised under pastoral system. Data were collected from a total of 35 camel owners. Field surveys from 12 delegations of the governorates of Kebili, Tozeur and Medenine were used. Result surveys and statistical analysis of morphometric data highlighted that the only raised camel breed is "Maghrebi" represented by different ecotypes with different body measurements. According to farmers, animals are mainly kept for meat production while camel milk is rarely commercialized (14%) with an average daily yield of 2.5 liters. Pastoralists practice mobile animal husbandry and camels are grouped from November to next March which coincide with oestral season "El hdad". The she-camel reaches sexual maturity at 3 to 4 years while males at 4 to 5 years. Generally, one stallion can cover 20 to 40 she-camels in one season. Regarding the economic importance of camel for southern region inhabitants, a national strategy was established, and many efforts are made in order to improve camel flocks' production in Tunisia.

Keywords. Camels – Southern Tunisia – Pastoral system – Surveys.

Gestion des troupeaux de chameaux sous système pastoral dans le sud de la Tunisie

Résumé. *Les camélidés jouent un rôle important dans la vie de la population du sud Tunisien avec 90% du troupeau élevé dans cette région. L'objectif de cette étude est de décrire les pratiques d'élevage, la structure du troupeau, les pratiques ethno vétérinaires et les paramètres de production des dromadaires élevés sous-système pastoral. 35 enquêtes ont été réalisées auprès des éleveurs dans les gouvernorats de Kébili, Tozeur et Médenine pour la collecte des données. Les résultats des enquêtes et l'analyse des données morphométriques ont montré que la seule race cameline élevée est « Maghrebi » représentée par ses différents écotypes et différentes mesures morphologiques. Selon les éleveurs, les animaux sont principalement élevés pour la production de la viande alors que le lait est rarement commercialisé (14%) avec un rendement journalier moyen de 2,5 litres. Les pasteurs pratiquent la transhumance et les animaux sont groupés entre Novembre et Mars, ce qui coïncide avec la période œstrale « El hdad ». La chamelle atteint sa maturité sexuelle à 3 à 4 ans alors que le mâle à 4 à 5 ans. Généralement, un seul dromadaire peut saillir 20 à 40 chamelles en une saison sexuelle. Vu l'importance économique de l'élevage camelin pour les habitants du sud, une stratégie nationale a été mise en place et plusieurs efforts ont été fournis pour améliorer la production des troupeaux camelins en Tunisie.*

Mots-clés. *Camélidés – Sud Tunisien – Système pastoral – Enquêtes.*

I – Introduction

The camel stock is estimated to be about 37 509 691 in the world (FAOstat, 2019). The family *Camelidae* includes six living species; however, the single-humped dromedary (*Camelus dromedarius*) is the most numerous and widespread of domestic camel specie (Fitak *et al*. 2016). According to the FAOstat (2019), the camel population in Tunisia is around 237 516 heads while the official statistics of Livestock and Pasture Agency (2017) indicates 80,000 females mostly found in the southern region of the country.

Besides to its cultural and patrimonial value, camel breeding is of great economic importance representing an average of 43% of family labor for the population of the South-East of Tunisia (Tardif *et al*., 2014). Many believes were attributed to camel milk as: low cholesterol; cure gastroenterological diseases; cure diabetes; aphrodisiac properties; helping to autistic kids; and cure cancer.

The present paper aims to describe camel pastoral system in southern Tunisia and generate baseline information that will help improve camel production and livestock productivity.

II – Material and methods

The study took place in the governorates of Kebili, Tozeur and Medenine in southern Tunisia. The study sites were selected based on the presence of higher camel population. The distribution of camel owners across the sample's sites are 13, 17 and 5 from Kebili, Tozeur and Medenine governorates, respectively. A survey was undertaken to obtain information on camel husbandry and breeding practices, herd structure, traditional veterinary practices and animal production parameters. In addition, six body measurements were taken on she-camels from different ecotypes and statistical analysis were performed using R software version 3.6.2.

III – Results

1. Camel owner's characteristics

Regarding the level of education among camel owners in the study area, it was found that 35% of them were illiterate, while 27%, 29% and 9% had completed primary school, post-primary school and university studies, respectively. Furthermore, the results showed that most camel owners owned only camel (40%); followed by those who owned camel, sheep and goats (31%); then those who owned camel and sheep (17%). Few of them owned camel and goat (12%).

2. Herd structure and composition

In southern Tunisia, camels are primarily herded for meat production under an extensive pastoral system. More than half of camel owners have stated that they have obtained their herds by heritage. The total number of camels owned in our sample is 3,335 and the overall mean number of camels owned per person was 98. The Maghrebi camel is the only breed raised and it is represented by different ecotypes: in Kebili governorate, we found Merzougui (84%), Ghiloufi (8%) and G'oudi (8%) ecotypes; in Tozeur governorate, Ghribi (41%), G'oudi (24%), Hmadi (23%) and Abidi (12%) ecotypes were encountered and in Medenine governorate, there are Ardhaoui (80%) and crosses (20%).

Other than ecotypes, camels differ by their coat color and their body measurement. In fact, five coat color have been identified, namely: white "Bidha", red "Hamra", Yellow "Safra", blue "Zarga" and blonde "chagra". Concerning body measurements, six measures have been taken namely: neck circumference, neck length, height at hump, height at withers, hindlimb length and forelimb length.

The body measurements were taken on female camels in 23 herds of 11 delegations of southern Tunisia. The correlation coefficients have been calculated in order to measure the relationship between the different body measurements and significant coefficients were recorded between several variables. These coefficients ranged from 0.26 between Height at withers and forelimbs length to 0.73 between forelimb and hindlimb length. The obtained results are in accordance with those of Chniter *et al.* (2013) concerning the significance of the correlations between Height at withers and forelimbs length (0.26 *vs* 0.14) and between height at hump and Height at withers (0.57 *vs* 0.73). The effect of ecotype and age has been also studied. Ecotype has a highly significant ef-

fect (p< 0.001) on the neck length and circumference and on the fore and hindlimbs length. Those results show that even if the classification of animals is based on their tribal affiliation, it could have a phenotypic or even a genetic justification which may be due to the effect of climate and environment (Mahrous *et al.,* 2011; Ishag *et al.,* 2011; Almathen *et al.,* 2012 cited by Abdallah *et al.,* 2012; Chniter, 2013; Meghelli *et al.,* 2020). Regarding age, no significant difference was observed and this could be due to the age of the animals used in this study. For means and standard deviation of the different body measurements, results are shown in Table 1.

Table 1. Means and standard variation of phenotypic body measurements among different Tunisian camel ecotypes

Ecotype	Neck circumference (cm)	Neck length (cm)	Height at hump (cm)	Height at withers (cm)	Hindlimb length (cm)	Forelimb length (cm)
Merzougui	67 ± 7.6	89 ± 16.6	190 ± 8	176 ± 7.4	142 ± 6.8	116 ± 7.4
Ghiloufi	63 ± 4.5	104 ± 5.5	194 ± 8	180 ± 7.1	141 ± 2.1	111 ± 2.7
G'oudi	69 ± 10.6	105 ± 5.1	200 ± 13	175 ± 6.7	139 ± 0.5	112 ± 4.7

The Merzougui camels have longer fore limbs. For the height at the withers, the hindlimb length and the neck circumference, there was no significant difference between Merzougui, Ghiloufi and G'oudi camels, while for the height at the hump, Ghiloufi exceeded the values of the other ecotypes. Regarding the length of the neck, the mean values showed that the Merzougui ecotype has a shorter neck than the others (P <0.05). Those variations could also be due to the activities and the work performed by the dromedary (Tandoh *et al.,* 2018), the environment effect (Meghelli, 2020), the breeding system and the history of those ecotypes, especially from a genetic point of view.

3. Herd management

In most cases, herd management is under the supervision of the camel herder (74%). During the period from September to March, herders stay in a portable tent that give them the flexibility to move around in search of grazing lands and water. The tent includes many utensils such as gas bottle, potable water, ancient stove, pillows, carpets. The camp is set up near to water source. In Tunisia, herders moved their animals between March and October, then camels are grouped, identified using modern (ear tags) and traditional methods (branding), vaccinated and received feed supplementation between September and March which coincides with heat and birth season.

There are also many regular tasks that are carried out by the camel herder such as watering and feeding animals, checking their feet's in search of thorns that would hurt them, investigating diseases and operating them when necessary, detecting pregnant females and watching over them when giving birth. The camel herder should know when the camel is ready to be milked; in fact, she-camels are milked only in the morning and in the evening and the milk is stored in a brown leather bag made of goat skin. Camel milk is an important component of the camel herder diet together with a traditional dish named "Zommita" and which is made of roasted barley-based flour melted with other seeds and components, grinded, sieved and then mixed with olive oil and water. It's important to mention that all pastoralists consider camel milk selling a taboo. Moreover, an experienced camel herder is required to know the tracks that lead to the herd. In case of loss of any of the camels, he must be a good clues detector: he inspects consumed bushes, excrement traces and animals' footprints to find them.

By visiting several farms, we have noticed a difference in the clothing of the camel herder and the owner. The first, who moves a lot and comes into direct contact with the animals, dresses in pants and shirt. As for the second, who controls his herd from afar, he wears loose clothing such as Jebba and only intervenes when necessary. Furthermore, while visiting a camel herd, strict instructions

are given by the herder as well as the camel owner. It's advised not to get too close to the camels, and especially to the stallion, to avoid their aggressiveness. It's also strictly forbidden for fragrant people to approach to newborn camels under one week of age to reduce the risks of their death.

4. Reproduction parameters

Camels are seasonal breeders. In Tunisia, they come into heat during the breeding season, generally from November to April. This period is characterized by low temperature and abundant rainfall. However, camels are more active during the period from December to March. Females are generally first bred at the age of 3 to 4 years old, but some of them might be used at the age of 2 years if they obtained 70% of their adult body weight and they are named "madhlouma". In males, puberty is reached between 3 to 4 years of age. Males are used for breeding from the age of 5 to 6 years old with a mean age of 5.6 years.

Generally, one stallion can breed 20 to 40 she-camels in one season. In the present study, most of the stallions used were autoproducts which can increase inbreeding within the flock. The most important traits in choosing a breeding stallion are, according to camel owners, their mother's milk production rate, coat color, tail length and size, neck length and testis size. For the remaining herds, stallions were purchased; for Medenine and Tozeur camel owners, stallions are generally bought from Tataouine and Kebili (Douz). Whereas, for Kebili camel owners, stallions are purchased from Tataouine. It's important to mention that, over 29% of the herds, have no breeding camel within a flock size ranging from 5 to 30 heads. In this situation, stallions are borrowed from neighbors camel owners.

Concerning she-camels, the signs of pregnancy are frequent urinating and carrying the tail in the horizontal position in the presence of the male or even in the presence of foreign visitors, according to camel herders. The gestation period is about 12 to 13 months. Our finding shows that this period ranged from 365 to 389 days with a mean of 367 days. Most calves are born from January to February. According to the informants, some cases of calves' mortality and she-camels injury have been recorded following jackal attacks. Before giving birth, she-camel loses appetite, separates itself from the herd and hide behind bushes. Most of the time, she-camels did not need any human assistance; nevertheless, the herder must stay close to the camel in case of any dystocia. Calving interval is around 2 years, still shortening it will ensure better productivity and profitability of the herd.

5. Production parameters

In southern Tunisia, meat is the main product of the camels. In fact, calves are sold between 7 and 17 months of age with a body live weight ranging from 100 to 250 kg and a price ranging from 1200 to 1500 TD (Tunisian Dinars).

Concerning milk production, camel owners and herders selected the breeding dairy she-camel based on phenotypic traits, such as developed milk vein, size of the udder, teats length and a large abdomen. Lactation duration is from 16 to 19 months where the presence of the calf during milking is imperative. She-camels are milked once (20%) to twice (80%) per day and the average daily milk yield per she-camel is 2.5 liters (marked by a large variability ranging from 1 to 10 liters). It's important to mention that, in the study area, camel milk is though to have medicinal and therapeutic properties. In fact, this milk is widely used to reduce the blood glucose level and to treat blood cancer especially when it's mixed with urine in addition to it's use in the improvement of the healing of fracture bone due to it's high level in Calcium.

A. Culling

Since livestock is bred to produce meat or milk, the herd must be culled to a certain rate. In this study, out of 35 camel owners, 24 have recourse to culling. Age was the most prevalent reason of

culling (67%) followed by infertility (21%) and health state (12%). The rest of the camel owners (31%) refuse to cull their animals regarding their close relationships with them. In fact, camels represent not only a source of income for the pastoralists, but also their identity.

B. Calf management and weaning

Among the camel owners interviewed in Kebili, Tozeur and Medenine, most camel of them wait the calf to wean naturally. However, for the rest, they practice abrupt weaning using traditional techniques such as udder nets named “chmel” which covered the teats and prevented the calf from suckling. Other methods are used such as the impregnation of the calf with lime or with his mothers’ excrement so that she could no longer recognize her baby’s smell and she flee from him. Camel owners wean calves at an age ranging from 6 to 18 months and with a mean age of 11 months. In fact, calves fattening is not widely practiced in the study area and this is due to the high cost of feed products.According to our results, 91% of camel owners have problems related to the procurement and payment of those feeds. For the sale of calves, 69% of the interviewees stated that they sell their animals just after weaning at a mean age of 12.7 months. The age of sale ranges from 7 to 24 months.

Concerning female young camel, commonly known as “Bakra”, they are rarely sold. The sale is generally sporadic and if necessary. In fact, the State is proposing a subsidy on the conservation of young female camels in order to increase the number of female units and to conserve the national herd. This grant is 700 TD spread over 3 tranches and is subject to several conditions.

6. Camel health management and ethno-veterinary medicine

Organized annual campaigns are carried out by the office of livestock and pasture and the veterinary service during the period October to March, to control trypanosomiasis and scabies. Other than vaccination, this campaign includes animal identification using tags and young females rearing subsidization. Furthermore, our findings show that all camel owners need private veterinarian services. The common diseases that infect camel in the study area are scabies, camel pox, ringworm and trypanosomiasis. However, the control of those diseases remains difficult due to herd mobility and farms dispersion.

Thus, 57% of the interviewees turned to ethno-veterinary remedies of camel diseases refering to “the knowledge, skills, methods, practices, and beliefs about animal health care found among the members of a community” (McCorkle, 1986). The results revealed that the traditional healthcare practices adopted to cure skin diseases such as scabies, as well as mastitis is tarring. The tar is extracted from a shrub called “retem” (*Retama raetam*). The camels suffering from ringworm, commonly known as “guarâa” or “El âarr”, are treated either with burnt diesel oil (heated in winter and cold in summer) or with milk and salt. The local healers fed a mixture of caraway, fenugreek and coriander seeds to camels having abdominal bloating. Fenugreek seeds are also used to stop diarrhea. The routine practice followed by the local healers against respiratory diseases is cauterization of the armpits and neck and ocular affections, such as keratoconjunctivitis, are treated with crushed glass which is sprinkled on the animal’s eyes.

IV – Conclusion

In the study area, camels are traditionally reared under pastoral production system and they are mainly herded for meat production. Camel milk, which is characterized by its therapeutic value, its sale is always considered a taboo. Camel owners are facing various constraints such as high feeding costs, diseases and jackal attacks. For future prospects, national efforts should be made to convince camel owners to invest in milk production. Also, to put the bases for the implementation of a modern system of selection for morpho-functional traits of economic interest to increase drom-

edary productivity in Northern Africa. More investment and governance in the camel sector are needed. The new strategy should give a clear direction on how and in which way we can boost camel owners' investment and agribusiness development and foster camel milk trade.

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Environment and biometry in the sheep breeds of North-West Portugal

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Abstract. The North-West region of Portugal has undergone a profound change in its agricultural structure, with the abandonment of agricultural activity but increasing the use of autochthonous sheep breeds. These sheep, which are exploited for meat production, can belong to Bordaleira Entre Douro e Minho (BEDM) breed, usually accompany cattle in the pasture, well-formed and moderately developed or Churra do Minho (CM), small sheep with coarse and long wool, that graze exclusively in herds, traditionally kept in turn by the farmers. The aim of this study is to evaluate the adaptability to different ecosystems and the environment influence, in particular altitude, to the breeds morphometric parameters. A total of 1394 BEDM females and 908 CM females were analysed and conformation, productivity and mobility measures were estimated. Our results present significant differences (P≤ 0.05) between breeds and age, with higher values in BEDM, relatively to structure parameters. Significant differences were found, regarding breed in functionality. These biometric differences contribute to explain the geographic distribution of breeds, BEDM occupying the valleys, rarely exceeding 600m in altitude and CM the highest mountains where poor soils predominate, with rocky outcrops and sporadic agricultural crops – scrub, low grass and shrub plants, with low energy levels and poor digestibility.

Keywords. Sheep breeds – Environment – Altitude – Biometric measures – Phenotype – Breeding.

L'environnement et la biométrie chez les Races Ovines du Nord-ouest du Portugal

Résumé. *La région du nord-ouest du Portugal a subi un profond changement dans sa structure agricole, avec l'abandon de l'activité agricole mais en augmentant l'utilisation de races ovines autochtones. Ces ovins exploités pour la production de viande peuvent appartenir à la race Bordaleira Entre Douro e Minho (BEDM), accompagnent généralement les bovins au pâturage, bien formés et moyennement développés ou Churra do Minho (CM), petits ovins à laine grossière et longue, pâturés exclusivement en troupeaux, traditionnellement gardés à leur tour par les agriculteurs. L´objective de cette étude est d'évaluer l'adaptabilité à différents écosystèmes et l'influence de l'environnement, en particulier l'altitude, sur les paramètres morphométriques des races. Un total de 1394 femelles de la race BEDM et 908 femelles de race CM. ont été analysés et les mesures de conformation, de productivité et de mobilité ont été estimées. Nos résultats présentent des différences significatives (P ≤ 0,05) entre races et âge, avec des valeurs plus élevées chez BEDM, par rapport aux paramètres de structure. Des différences significatives ont été trouvées, concernant la race, dans la fonctionnalité. Ces différences biométriques contribuent à expliquer la répartition géographique des races, occupant BEDM les vallées, dépassant rarement 600m d'altitude et CM les plus hautes montagnes où prédominent les sols pauvres, avec des affleurements rocheux et des cultures agricoles sporadiques – broussailles, herbes basses et arbustes, à faible niveaux d'énergie et mauvaise digestibilité.*

Mots-clés. *Races ovines – Environnement – Altitude – Biométrie – Phénotype – Elevage.*

I – Introduction

The domestication of animals and plants represented one of the most important technological transformations in the history of mankind (Arbuckle & Atici, 2013) and appears to have started after the end of the last ice age. Archaeological findings document that the domestication of small ruminants started (approximately 10,000-11,000 BP) in the "Fertile Crescent" and "Levant" region, which to-

day comprises the territory from the Middle East to Turkey, passing through the island of Cyprus (Horwitz *et al.*, 2000; Vigne *et al.*, 2011). Sheep are ubiquitous across pre-historic steppe archaeological contexts dating from the Early Bronze Age, being a small and mobile animal, as part of a pastoral package of horse, cattle, and goats (Haruda *et al.*, 2019).

Archaeological evidence also points to the dispersion of animals from Southwest Asia, along the Mediterranean coast and throughout central Europe (Pereira *et al*., 2006). In the western part of the Iberian Peninsula, the vestiges date from around 6200 BP and reflect a rapid dispersion, in agreement with the process of maritime colonization by Mediterranean civilizations (Zilhão, 2001).

Genetic studies point out that all the existing domestic sheep have their origin in the Asiatic mouflon (*Ovis orientalis*) from the Taurus and Zagros mountains (Zeder, 2017), and mitochondrial DNA sequencing techniques supported this hypothesis, by excluding the contributions of Urial (*Ovis vignei*) and Argali (*Ovis ammon*) to the existing populations of *Ovis aries* (Hiendleder *et al.*, 2002).

The study the mtDNA of 7 Portuguese breeds, belonging to the 3 main Iberian branches: Merino, Churra, and Bordaleiro, demonstrated an extremely high genetic diversity and found genetic strains that, until then, had only been found in Near East and Asia (Pereira *et al.,* 2006), which reinforces the thesis of dispersion across the Mediterranean by sea (Pedrosa *et al.,* 2007). Archaeological and genetic studies indicate that the territory of the Iberian Peninsula seems to have been an important area for the production and improvement of this species (Davis, 2008), currently illustrated by the 16 indigenous breeds existing in Portugal and the 44 in Spain (BOE, 2019).

In the Northwest of Portugal there are 2 breeds of autochthonous sheep: the “Bordaleira de Entre Douro e Minho” (BEDM) and the “Churra do Minho” (CM). These breeds occupy, preferably, different strata of the orography of this region and are explored in a distinct way. Although BEDM was already mentioned in the 1870 official census, there was no conservation program until officially recognized as an autochthonous breed, in 2003. At that time, CM was only considered as a variety of BEDM and only become recognised officially as an autonomous breed in 2007. Selection programs have been carried out to eradicate the genetic influence of BEDM in this population, by the exclusive use of CM male breeders and selecting new breeders by the size and wool type.

The Bordaleira de Entre Douro e Minho breed is a medium size sheep, belong to the branch of Bordaleiro and occupy the areas of half slope or valleys, which rarely exceed 600m in altitude. This region has a moderate Atlantic climate, characterized by relatively cool summers and mild winters, with annual thermal amplitudes that rarely exceed 10 ºC, and abundant rainfall, especially in autumn and winter. The soils of this region, although poor (generally deficient in phosphorus, magnesium and calcium), allow for a reasonable forage production enabling the obtaining of modest but significant zootechnical results (DGAV, 2013). The profitability of these small size herds is primarily due to its meat production, either by lamb’s commercialization or self-consumption. Its manure production is highly valued for fertilizing ornamental gardens and the cleaning and maintenance of the fields are also functions of this breed, that enable its existence and allow the conservation of the typical landscape of the Minho region. Wool, of the Bordaleiro type, with its average quality and devalue, represents more a burden than an asset (Dantas, 2003).

The Churra do Minho is a light-sized sheep breed, with coarse, long and drained wool (Churra type). These animals inhabit the highest areas of the mountains of Northwest Portugal, almost always above 800m altitude, and are raised in free grazing, constituting relatively numerous herds, often accompanied by Bravia goats’ breed. This region has an Atlantic climate with markedly continental influences, characterized by very cold winters, with prolonged periods of snow, numerous days of frost and heavy rainfall, which condition the entire vegetation cover of the mountains (DGAV, 2013). CM breed maintains a very homogeneous and unadulterated population, mainly due to its high rusticity and adaptation to this type of production system, characterized by the scarcity of re-

sources and adverse climatic conditions (Teixeira,1994). The higher pastures, where these sheep normally graze, with skeletal soils of granitic origin, have a predominantly shrubby flora and with some poorly developed grasses. This strict and restrictive food base, of low quality and digestibility, greatly conditions the development and survival of the animals that feed on it, as well as the populations that depend on them. Thus, allied to the grazing-pasture practiced in these regions, sporadic agricultural crops (maize, potatoes and vegetables) and spontaneous fodder to complement the livestock on winter days can be found on areas uprooted from the hills and surrounded by immense cliffs (DGAV, 2013).

Several studies of morphometric index are performed worldwide, the vast majority directly related to the breed characterization and conformation (Yunusa *et al*., 2013; Costa *et al*., 2014, Markovic *et al*., 2019). The use of zoometric measures as a strategy to provide a reasonable representation of the differences among breeds and contribute to a better understanding of differences in production systems regarding the environment, nutrition and breeding areas, is an important research topic in sheep populations, particularly in Portugal (SEAIA, 2013; Carolino *et al*., 2013).

The aim of this study is to evaluate the distancing, in morphological terms, of the two breeds and within different age groups, since the separation of the herd book, in order to support the breeding and selection programs.

II – Materials and methods[1]

1. Sample size and distribution

The whole sample comprised 2252 ewes, distributed by 1344 females (F) of BEDM, and 908 females of CM, all over 9 months old and registered in the herd book of the respective breed. The BEDM sheep were selected from 37 herds (representing 21% of the total breeders) and the CM females came from 10 farms (15% of the total) in the region considered to be their breeding area (districts of Braga, Porto, Viana do Castelo and Vila Real).

The BEDM is bred in small agricultural units, normally self-subsistent, constituting small herds that are exploited as a complement to cattle, generally considered as the main production of the farms. These herds, when shepherding together, allow a greater use of forage availability and a profitability of surpluses.

The CM sheep farming system is typically an extensive system. Characterized by medium-sized herds, with about 70 animals per farm, inserted in small mountain agricultural units that take advantage of the large common lands in the region.

2. Zoometric measures

Biometric variables were measured and following procedure, according to FAO (2012) guidelines for adult animals (older than 9 months), is shown in Table 1. Quantitative data (ICCAR, 2008) was obtained using a measure tape and an angle finder.

1. The trial was carried out in accordance with EU Directive 2010/63/EU; it complied with the Portuguese legislation on animal care (DL n. 113, 7 August 2013), and adhered to the internal rules of the Polytechnic Institute of Viana do Castelo.

Table 1. Biometric variables and measuring procedure to obtain them from the animals

	Variable	How to measure It	Units
Standard Traits	Stature (St)	from the top of the spine in between the shoulders to ground	cm
	Chest width (CW)	the inside surface between the top of the front legs	cm
	Body length (BL)	from the cranial point of the humerus greater tuberosity to the ischial tuberosity caudal point	cm
	Bone thickness (BT)	thickness of the cannon bone in the forelegs	cm
	Rump length (RL)	distance between hips to pins	cm
	Thurl width (TW)	distance between thurls	cm
	Rump angle (RA)	the angle of the rump structure from the hooks (hips) to pins	º
Leg Traits	Rear leg set side view (RLSV)	angle measured at the front of the hock	º
	Rear leg set rear view (RLRV)	distance between hocks	cm
	Locomotion (L)	the use of legs and feet, length and the direction of the step	cm
Udder Traits	Rear udder height (RUH)	the distance between the bottom of othe vulva and the milk secreting tissue	cm

3. Data analysis

Descriptive statistics [mean, standard deviation (SD] were generated for all the variables in the dataset. As recommended by ICAR Guidelines, for the quality of data, the animals were grouped in 6 categories of similar age. The first group under 18 months old (group 1), and then considering a productive cycle of 9 years, 5 more categories were established with an interval of 17 months: from 19 to 36 months old (group 2); from 37 to 54 months old (group 3); from 55 to 72 months old (group 4); from 73 to 90 months old (group 5); more than 91 months old (group 6), in order to evaluate biometric modifications between age groups and within breeds.

A Shaphiro-Wilk's test (Shapiro and Wilk,1965) was previously carried out to analyse data distribution normality. Breed and age group effects were determined by Chi-squared or the Tukey's test and ANOVA procedure was used to test differences in age, within breed and between the different data categories, using the general linear model of IBM SPSS Statistics 23.0. All statements of significance were based on testing at the P, 0.05 level. The Pearson phenotypic correlation matrix was estimated for zoometric measures (ZM).

III – Results

1. Breed effect

The morphometric analysis indicated highly significantly ($p \leq 0.05$) breed effect, as shown in Table 2 and 3, with the superiority of the BEDM ewes. Concerning stature analysis, the BEDM breed females were significantly ($p \leq 0.05$) the tallest, largest and biggest (CW and TW), with a greater rump length. Conversely, the CM breed ewes were the significantly ($p \leq 0.05$) less robust (smaller, thinner and shorter), and presented the smallest rump angle and the least bone thickness. The superiority ($p \leq 0.05$) of BEDM females was also verified regarding leg and udder traits, suggesting its higher productive potential.

Table 2. Effect of breed in the different standard traits (cm and º) in BEDM and CM breeds

		Standard traits													
		Stature		Chest width		Body length		Bone thickness		Rump lenght		Thurl width		Rump angle (º)	
Breed	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
BEDM	1344	60.4[a]	3.5	20.6[a]	2.9	67.1[a]	5.2	8.1[a]	0.5	22.6[a]	1.8	19.9[a]	2.1	41.8[a]	5.9
CM	908	56.4[b]	3.4	18.4[b]	1.8	63.1[b]	5.4	7.8[b]	0.5	20.4[b]	2.3	17.7[b]	2.2	42.6[b]	7.1
TOTAL	2252	58.8	4.0	19,7	2.7	65.5	5.6	8,0	0.5	21.7	2.3	19.0	2.4	42.1	6.4

[a,b] Different letters in the superindex are indicative of the existence of significant differences among breed for the stature measures ($p \leq 0.05$). SD: Standard Deviation.

Table 3. Effect of breed in the different leg and udder traits (cm and º) in BEDM and CM breeds

		Leg traits						Udder traits	
		Rear legs set rear view		Rear legs set side view (º)		Locomotion		Rear udder height	
Breed	N	Mean	SD	Mean	SD	Mean	SD	Mean	SD
BEDM	1344	10.9[a]	2.5	48.2[a]	7.5	6.3[a]	0.7	5.7[a]	2.2
CM	908	10.1[b]	2.7	46.5[b]	8.3	6.0[b]	0.9	5.5[b]	1.7
TOTAL	2252	10.5	2.5	47.5	7.9	6.2	0.8	5.6	2.0

[a,b] Different letters in the superindex are indicative of the existence of significant differences among breed for the leg and udder traits ($p \leq 0.05$). SD: Standard Deviation.

2. Age group effect

To evaluate the breed zoometric variability and the morphological behaviour over age, age group parameters were estimated. When considering the age group effect (Figure 1) in structure traits, significant differences ($p \leq 0.05$) were observed in all parameters, between all age groups and breeds, except for the thurl width, between the first, fourth, and sixth groups. Within breed, zoometric modifications, also with the exception of the thurl width, were observed ($p \leq 0.05$), between the first and second age group, in all the measurements. Also, in this trait, and regarding CM breed, no significant differences ($p > 0.05$) were observed, between all age groups.

3. Phenotypic correlations

The phenotypic correlations between all measurements are given in Table 4, for both breeds. High significant ($p \leq 0.01$) positive correlations were recorded, for all breeds, between the stature and body length (0.56 and 0.51), body length and chest width (0.50 and 0.62), rump length (0.59 and 0.55), rump angle (0.60 and 0.50) and rump length and rump angle (0.67 and 0.78), respectively for BEDM and CM. Similarly, in CM, high significant ($p \leq 0.01$) positive relationships were observed for rump angle and stature (0.52), chest width (0.62) and bone thickness (0.52). Significant ($p \leq 0.01$) negative relationships were obtained for the leg traits, between the rear leg set side view and rump angle (-0.14 and -0.22), rear udder hight (-0.27 and -0.06), rear legs front side view and rump angle (-0.17 and -0.20), rear udder hight (-0.08 and -0.10), for BEDM and CM females, respectively.

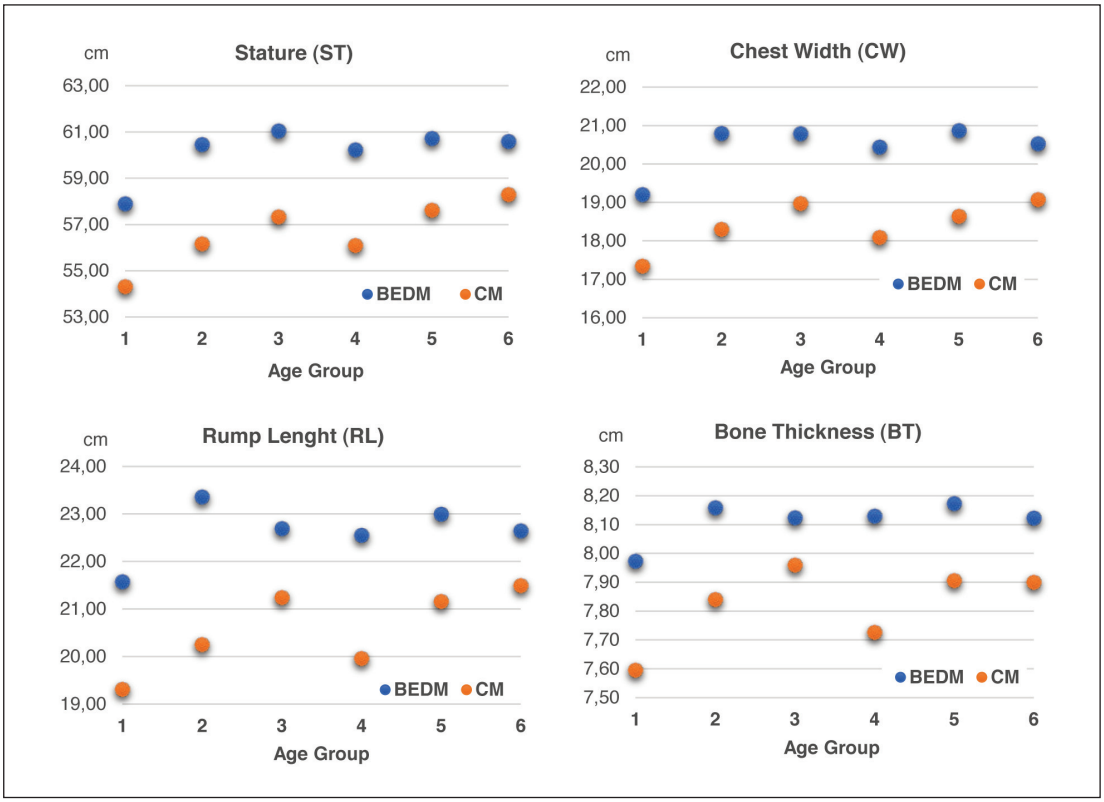

Fig. 1. Effects of age group and breed in the different Standard Traits in BEDM and CM breeds.

Table 4. Pearson's Correlations between traits for BEDM (n:1344, below diagonal) and CM (n: 908, above diagonal) breeds

Breed		Churra do Minho (CM)										
Bordaleira de Entre Douro e Minho (BEDM)	**Trait**	**ST**	**CW**	**BL**	**BT**	**RL**	**TW**	**RA**	**RLSV**	**RLFV**	**L**	**RUH**
	ST		0.443**	**0.510****	0.468**	0.450**	0.040	**0.523****	-0.250**	-0.177**	0.128**	-0.040
	CW	0.382**		0.501**	0.475**	**0.624****	0.102**	**0.622****	-0.069*	-0.072*	0.120**	0.030
	BL	**0.564****	0.414**		0.414**	**0.549****	-0.083*	0.499**	-0.215**	-0.020	0.114**	0.159**
	BT	0.252**	0.227**	0.381**		0.449**	0.156**	**0.516****	-0.060	-0.134**	0.114**	0.000
	RL	0.444**	0.**498****	**0.591****	0.332**		0.040	**0.785****	-0.153**	-0.084*	0.128**	0.138**
	TW	0.040	0.030	-0.030	0.020	0.010		0.084*	-0.087**	-0.238**	0.095**	-0.030
	RA	0.440**	0.481**	**0.598****	0.360**	**0.666****	0.000		-0.222**	-0.204**	0.143**	0.126**
	RLSV	0.030	-0.101**	-0.040	-0.067*	-0.088**	0.040	-0.143**		0.237**	-0.159**	-0.268**
	RLFV	-0.102**	-0.102**	-0.140**	-0.119**	-0.063*	-0.050	-0.167**	0.249**		-0.084*	-0.106**
	L	0.030	0.030	0.093**	0.107**	0.115**	-0.010	0.020	-0.080**	-0.010		0.010
	RUH	0.000	-0.065*	0.020	0.079**	-0.040	-0.067*	-0.040	-0.063*	-0.083**	0.086**	

ST: stature; CH: chest width; BL: body length; BT: bone thickness; RL: rump length; TW: thurl width; RA: rump angle; RLSV: rear leg set side view; RLFV: rear leg set front view; L: Locomotion; RUH: rear udder hight.

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.001 level (2-tailed). In bold, if high correlated > 0.5.

IV – Discussion

To define and implement breeding programs, morphological traits are essential parameters and dimensions of certain morphological variables could make them suitable, from a productive point of view, for meat (breast measurement) or milk productions (rear leg set side view, rear leg set front view) (Gootwine, 2020).

The studied populations are reared in geographically common areas, with frequent mixing of the breeding animals, which also contributed to the recent breeds genealogic register separation. The phenotypic divergences among them, as body measures differences, imply larger distances among breeds and the zoometric parameters are essential for establishing a morphological breed standard with visual conformation appraisal and, consequentially, to create genetic improvement programs (Gutierrez-Gil *et al.*, 2011).

The morphometric measurements show highly significant ($p \leq 0.05$) breed effect, with the superiority of the conformation traits in the BEDM ewe, being the highest, largest, longest and with the highest bone thickness and thurl width, and the CM females with the higher rump angle, associated to lower fertility and litter size (La Fuente *et al*., 2011; Haldar *et al.,* 2014). Concerning the leg and udder parameters, significant differentiation ($p \leq 0.05$) between breeds with the superiority of the BEDM, in all traits. These results reflect the higher rusticity of the CM breed, well adapted to the less favourable environment, with low nutritional availability and productivity.

Zoometric measures are, generally, significantly different ($p \leq 0.05$), between breeds, for structure traits, during all age group, with the exception of thurl width (first, fourth and sixth age group), and body length (fifth and sixth age group). Higher variability was observed, regarding the leg and udder traits in both breeds and different group age. Breeding programs are still in an initial period, directed to body conformation traits, and low productivity and double-purpose production has neglected leg and udder traits selection.

The positive and significant correlations among the body measurements observed in all the groups (BEDM, CM) indicate high predictability among the variables (Pundir *et al*., 2011). The lower and negative correlations observed rump angle and rear leg traits and rear udder hight interpret the parameters' weakness in the breeds' productive and functional traits.

Environmental and biological factors can affect animal populations, especially through effects associated with differences in the agro-climatic conditions, natural resources and breed purpose (Bridley, 2011; Vasquez *et al*., 2017; Sérgio *et al*., 2018). The adaptation of the studied breeds to the agro-climatic, ecological and environmental conditions contribute to emphasise their morphological differences and allow to design strategies and improve breeding programs in order to protect and evaluate those autochthonous populations.

The production system, nature and evolution of crop-livestock systems, and cultural, economic and social factors, as cultural preferences, economic opportunities, depopulation and labour bottlenecks (Baltenweck *et al*., 2003), are strongly influenced by general economic environment (markets, agricultural policies, societal demands, trends in other sectors of the economy, global change) but also by environmental and social terms and their ecological, landscape and cultural diversity (Gibon, 2005; Bernués *et al*., 2011; Vouraki *et al*., 2020).

Life history theory suggests an individual morphologic adaptation that will overcome disturbances, minimizing risks during the most vulnerable life stages (Roff, 2002). Disturbance resilience or exploitation may be mediated by physiology and anatomy adaptation, conditioning the morphological characteristics of the new cohort (Grant and Grant, 1993; Astheimer *et al*., 1995). Genetic responses can also be a consequence of environmental disturbances by selective pressures on traits genetically heritable (Grant and Grant, 2003), modulating genetic polymorphisms (Semlitsch and Wilbur, 1989) or changes in genetic structure and diversity (Szczys *et al*., 2012).

Furthermore, habitat components, in particular resources, play a fundamental and important role in shaping the spatial distribution (or space use) and the animal behaviour (Strandburg-Peshkin *et al*., 2017). When behaviours are socially learned, shared within subgroups of the population and persist over time, they are recognised as culture (Laland and Hoppitt, 2003). Considering how learned behaviours can affect individual social decisions reveals the potential for culture to underpin the co-evolution between social structure and behaviour (Farine and Sheldon 2015).

Social behaviour can respond to changes in habitat configuration and the relationship between social structure, animal movement and habitat configuration has important implications for conservation (He *et al*., 2019). Understanding how habitat changes can affect animal movement should be carefully considered in the conservation of social species (Cantor *et al*., 2021), and in the present study, how the border habitat, the social behaviour and the animal movement contribute to their phenotypic characters and productive traits.

Environment, morphology and production are intimately interrelated in the sheep breeds of north-western Portugal. CM breed is extremely archaic, tolerant to harsh climates and poor-quality pastures, characteristic of mountain environments and Bordaleira breed is mostly dairy sheep and used in traditional crop–livestock systems in low-land regions. More studies should be conducted in order to determine the best traits to be used as selection criteria, to increase the animal production systems efficiency and facilitate a breeding programs adjustment to underline their productive potential.

V – Conclusions

New constraints, as climate change, can lead to similar changes in genetic and community structure through the combined effects of selective and neutral processes, and affecting biodiversity, breeds adaptation and productive traits. BEDM and CM are two autochthonous sheep breeds of the Northwest of Portugal, and technical data, such as zoometric measures as a tool in biometric characterization, is mandatory in the implementation of autochthonous breeds selection programs.

The results revealed the high positive differentiation between breeds, with the superiority of BEDM, in structure and functional traits, grazing areas, which rarely exceed 600m in altitude. Positive correlations were obtained between morphometric measurements and its advantages to define conformation, providing a simple practical methodological framework suited for management, characterization and conservation, to be used in selection programs.

Policies that support rural livelihoods, promote local genetic resources and value sustainable products, are a contemporary society requirement, in order to conserve and maintain biodiversity and the environment Sustainability, resilience and adaptive capacity are strategies of autochthons breeds' producers that are guardians of a unique genetic world heritage.

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The contribution of ARIMNet to address livestock systems resilience in the Mediterranean region

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Abstract. From 2010 to 2019, the ERA-Nets ARIMNet and ARIMNet2 developed transnational cooperation in the field of agricultural research between Mediterranean countries. Among the major issues that have been addressed, the sustainability and resilience of livestock systems have been the subject of several research projects co-funded by the countries participating in this programme. The different research projects funded have produced knowledge on the efficiency of crop-livestock systems, the adaptive capacity of different livestock systems, their vulnerability and resilience. The crop-livestock association was shown to be particularly relevant in the Mediterranean area, and require the implementation of appropriate policies and collective actions. In addition, the limitations and vulnerability of intensive dairy systems based on imported breeds and feeds have been shown. The advantages in terms of resilience and adaptability of systems based on local breeds were identified. The development of these systems requires the valorization by the market of the quality and specificity of their products. Appropriate public policies and coordination of value chain actors are needed to enable this recognition and development of these farming systems.

Keywords. EU programmes for funding Research – Mediterranean – Livestock systems – Local breeds – Crop-livestock association.

La contribution d'ARIMNet pour aborder les enjeux de résilience des systèmes d'élevage dans la région Méditerranéenne

Résumé. *De 2010 à 2019, les ERA-Nets ARIMNet et ARIMNet2 ont permis de développer la coopération transnationale dans le domaine de la recherche agronomique entre les pays Méditerranéens. Parmi les enjeux majeurs qui ont été traités, les questions de la durabilité et de la résilience des systèmes d'élevage ont fait l'objet de plusieurs de projets de recherche co-financés par les pays participant à ce programme. Les différents projets de recherche financés ont produit des connaissances sur l'efficacité des systèmes agriculture-élevage, la capacité d'adaptation des différents systèmes d'élevage, leur vulnérabilité et leur résilience. L'association agriculture-élevage s'avère particulièrement pertinente dans la zone méditerranéenne, et il existe de réelles opportunités pour renforcer ces systèmes par la mise en œuvre de politiques et d'actions collectives appropriées. Par ailleurs, les limites et la vulnérabilité des systèmes laitiers intensifs basés sur des races et des aliments importés ont été montrés. Les atouts en termes de résilience et d'adaptabilité des systèmes basés sur des races locales ont été identifiés. Le développement de ces systèmes passe par la reconnaissance de la qualité et de la spécificité des produits qui en sont issus et leur valorisation par le marché. Des politiques publiques adéquates et une coordination des acteurs de la chaîne de valeur sont nécessaires pour permettre cette reconnaissance et le développement de ces systèmes d'élevage.*

Mots-clés. *Programmes européens de financement de la recherche – Méditerranée – Systèmes d'élevage – Races locales – Association agriculture-élevage.*

I – Introduction

Despite their diversity and specificities, Mediterranean countries face common challenges when it comes to ensuring food security and socioeconomic development, while conserving natural resources and adapting to climate change. The challenges require research efforts at a regional scale.

Until recent years, coordination of research activities among Mediterranean Countries was weak, it was mainly driven through external incentives of research funding, mainly the European Union Frameworks Programmes for Research. The countries from the non-EU part of the Mediterranean had the possibilities to participate in the research projects, and that was clearly good opportunity to boost research activities and partnership. However, in these programmes, the priorities and the topics to be funded were decided among EU Member States. Thanks to the impulsion of different institutions and notably the CIHEAM, the idea of having a research programme co-shared among Mediterranean countries emerged.

Defining the common research priorities, choosing the tools to support joint activities and implementing them to foster multilateral cooperation was the objectives of the ARIMNet and ARIMNet2 Era-Nets, that have taken place since 2008. The final goal was to achieve the necessary critical mass and build a strong scientific community all around the Mediterranean. By joining their efforts and capacities under a common strategy, the Mediterranean research organizations and funding agencies can achieve a stronger impact on the sustainable development of the region. A total of 47 research projects, and more than 20 million euros have been spent during ten years (2011-2021). ARIMNet2 was followed by the launch of a large-scale initiative, the PRIMA programme, that capitalizes on the results obtained and practices implemented within ARIMNet network. As an initiative under Article 185 TFEU, the PRIMA programme is currently funding annually research and innovation collaborative projects in water resources and food systems domains, with similar but wider objectives.

The issue of the resilience of livestock systems was part of the agenda of ARIMNet and ARIMNet2. This article analyses how this has been addressed in the projects funded by ARIMNet and ARIMNet2, what advances in knowledge they have enabled and how they contribute to the challenges of socio-economic development and natural resource conservation in the region.

II – Objectives and achievements of ARIMNet and ARIMNet2

ARIMNet (Coordination of Agricultural Research in the Mediterranean) and ARIMNet2 were two ERA-Nets funded through the EU FP7 for the period 2008-2013 and 2014-2017 respectively. Largely implemented inside the EU as a major tool for enhancing cooperation in European research, the ERA-Net instrument was extensively used during the FP7 programme. However, it seldom involved non-EU countries, ARIMNet was unique in that sense that it gathers countries from North, South and East Mediterranean. As required in the ERA-Net tool, the funds for coordination among countries came from the EU FP7 whereas the funds to support multilateral research project as well as other joint activities are co-funded by participating countries. And this co-funding of common activities is the backbone of joint strategy.

ARIMNet involved 15 partners (national funding agencies and research institutions) from 11 countries and ARIMNet2 involved 24 partners from 15 Mediterranean countries.

Over the years, ARIMNet and ARIMNet2 have achieved important results, the main one being the co-financing of transnational research projects. Four calls were launched to support transnational collaborative research projects (Table 1). Gathering at least three different countries with one from EU country and one from Mediterranean non-EU country, were part of the conditions to apply to these calls. In 2017, the call for research projects was focused on young researchers, as a consequence of a dedicated summer school organized in 2016 to enhance young researchers' involvement.

Table 1. Characteristics of the four calls for research projects, funded through ARIMNet and ARIMNet2

Year of Publication of the Call	2011	2014	2016	2017
Type of project	Collaborative projects (min 3 countries)	Collaborative projects (min 3 countries)	Collaborative projects (min 3 countries)	Young Researchers collaborative projects
Countries participating in this call	Italy, Greece, Spain, Israel, Egypt, Morocco, Tunisia, Algeria, Turkey, France, Cyprus	Italy, Greece, Spain, Israel, Egypt, Morocco, Tunisia, Algeria, Turkey, Malta, France, Portugal, Slovenia, Croatia	Italy, Greece, Spain, Israel, Egypt, Morocco, Tunisia, Algeria, Turkey, Malta, France, Portugal, Slovenia, Croatia, Egypt, Greece, Spain, Morocco, Tunisia, Algeria, Turkey, France, Croatia, Slovenia	Egypt, Greece, Spain, Morocco, Tunisia, Algeria, Turkey, France, Croatia, Slovenia
Topics	1) Developing sustainable production in the context of increasing ecological and climatic stresses; 2) Food chain from production to consumption: enhancing the advantages of Mediterranean Agriculture and Food; 3) Sustainable management of landscape and resources used by agriculture	1) Developing sustainable production in the context of increasing ecological and climatic stresses; 2) Food chain from production to consumption: enhancing the advantages of Mediterranean Agriculture and Food; 3) Sustainable management of landscape and resources used by agriculture	1) Promoting sustainable agriculture for socio-economic development; 2) Valorising local products through food value chains improvement	1) Promoting sustainable agriculture for socio-economic development; 2) Valorising local products through food value chains improvement
Total funding available (Million €)	7	5.6	4.8	3.4

The analysis of the domains covered by the 47 projects funded during the all period (Figure 1) shows the diversity of topics covered. It shows also an imbalance between the projects addressing crop production (cropping systems plant health and valorisation of plant products) compared to the projects addressing livestock systems and animal production. Regarding the animal productions, four projects addressed issues related to livestock systems, three of them to animal health and three of them to animal product food chains and food technologies:

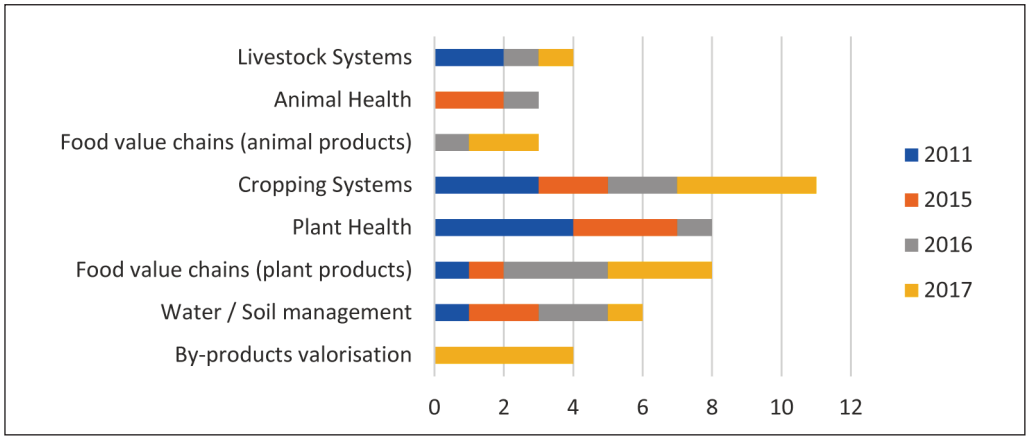

Fig. 1. Number of projects by ARIMNet and ARIMNet 2 funded per scientific domain.

Considering the main domain of this special issue of *Options Méditerranéennes*, about "Combining the diversity of resources and farming practices to ensure resilience of livestock farming systems at different scales", to analyze how the resilience of livestock systems have been addressed in the projects funded by ARIMNet, we choose to focus on the five following projects: CLIMED, DOMESTIC, PERFORM, BIOVISOL, CDCMT, CARAVAN (box 1).

Box 1. Selected projects funded by ARIMNet and ARIMNet 2

CLIMED (2012-2016 funded through ARIMNet 2011 Call) "**The future of Mediterranean Livestock Farming Systems: Opportunity and efficiency of Crops – Livestock Integration"** involved Egypt, Morocco, France. Its objective were: identifying efficient crop-livestock systems for better utilization of water, soil, crop residues, rangelands and increasing farm production to meet the rising local demand of safe animal products, assessing adaptive capacities, vulnerability and flexibility of the farming systems; Developing future scenarios and priorities for livestock development in the Mediterranean context.

DOMESTIC: (2012-2016- Funded through ARIMNet Call 2011) "**Mediterranean biodiversity as a tool for the sustainable development of the small ruminant sector: from traditional knowledge to innovation**" gathered partners from Greece, Morocco, Cyprus and France, was focused on sheep and goat local breeds. It aimed to investigate the factors that influence the sustainability of sheep and goat production systems, by examining the components of the production systems, the supply chain and the regulatory organization. The main results of this project concern the links between local breeds' management, and product valorisation.

PERFORM (2017-2020 ARIMnet2 Call 2016) **"Breeding and management practices towards resilient and productive sheep and goat systems based on locally adapted breeds"** gathered six partners from four countries (France, Greece, Morocco and Egypt). Its objective was to strengthen the capacity of local livestock systems to cope with changes and hazards and to support the livelihoods of rural families. The project focused on the changes of practices of farmers and other stakeholders involved in the dynamic of the local breeds, as the main lever associated with the evolution of the production systems.

BOVISOL (2018-2021, ARIMNet 2 Young Researcher Call 2017) **"Breeding and Management Practices of Indigenous Bovine Breeds: Solutions towards a Sustainable Future"**, involved researchers from Algeria, Tunisia and Greece). Its aim is to provide an overall perspective of the local bovine breeds and their production systems and of improvements that could be proposed in terms of animal breeding, feeding practices, hygiene conditions and product quality certification that would improve the productive system without altering its traditional label.

CDCMCT (2018-2021, ARIMNet 2 Young Researcher Call 2017) "**Characterization of dairy chain in Mediterranean countries and adoption of optimum technologies to improve dairy value chain**", 5 countries Algeria, Greece, Spain, France, Egypt. Farming practices in feed management and milking, storage, transport and processing as well as quality and safety of milk and/or dairy products will be assessed by analyzing physicochemical parameters, microbiologic profile, mycotoxins etc.

CARAVAN: ARIMNet2 Call 2016 (2017-2020) **"Toward a Camel transnational Value chain"** The project involved partners from 6 countries (Spain, Italy, France, Algeria, Morocco, Tunisia). It aimed at promoting integration along the dromedary value-chain. Standardization of animal identification and phenotype systems were conducted with the aim to contribute to genetic improvement. Processing technologies in the production of fermented milk were studied with the aim of improving practices towards quality and safety.

In this special issue, we will examine the scientific outputs of these different projects against the rational that was developed by the ARIMNet in its Integrated Strategic Research Agenda (ISRA) consortium in 2016.

III – The main challenges for livestock production systems in the Mediterranean countries as described in the ARIMNet2 Integrated Strategic Research Agenda

The Integrated Strategic Research Agenda, elaborated under the aegis of ARIMNet2 (ARIMNet2, 2016), was the result of a common reflection that identifies the priorities set in the different calls for research projects and other joint activities. It points out the food security, poverty alleviation and natural resource preservation nexus as the main challenge to be addressed (Figure 2). This led the ARIMNet2 partners to identify three objectives and define thematic priorities on which to focus their actions: 1) promoting a balanced territorial development 2) enhancing value chains, 3) increasing the efficiency and sustainability of production systems.

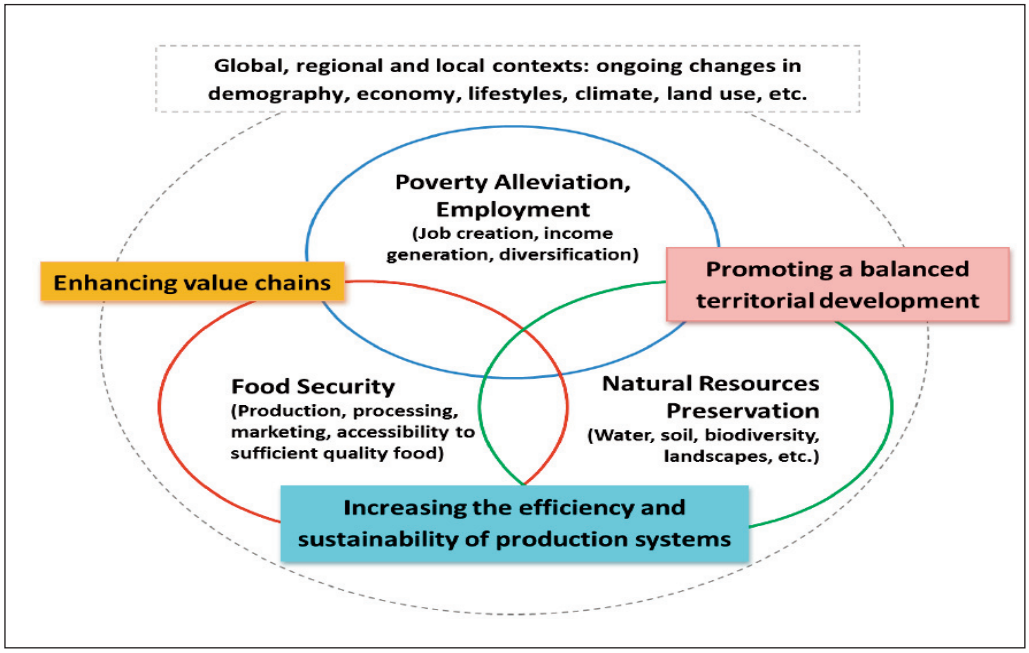

Fig. 2. The Mediterranean food security, poverty alleviation and natural resource preservation nexus in the ARIMNet2 Integrated Strategic Research Agenda.

The Mediterranean agriculture systems have known increasing pressures that include strong demographic growth, urbanization, increasing demand for animal products (especially in southern regions), a demand for more safe animal products, and a high competition for land and water. In this context, the livestock systems experience pressures on biomass to feed animals raise many challenges and sometimes competition in the trade-offs in the use of resources (land, water, and nutrients) that can affect the sustainable development of these systems.

Livestock activities are now recognized for their multiple roles in reducing vulnerability in fragile environment and their roles in diversification and intensification processes. However, the main rec-

ommendations of recent scientific assessments (IAASTD,2009, IPCC, 2019) provide evidence of the difficulties to capture the complex biological, social, and economic dynamics of the variety of challenges likely to confront future crop and livestock production and their integration. The Mediterranean livestock farming systems have also known important changes with the irrigation development and the social and political changes that have affected the livestock management (settlement, mobility, transhumance, etc.), the land tenure and land use, and then the sustainability of the whole production systems.

The South Mediterranean countries show an increasing demand for different animal products in link with the demographic growth and the emergence of a medium social class although North Mediterranean countries record a stagnating consumption of animal products of local origins (mainly sheep meat). These two trends question the ecological equilibrium and socio-economic viability in these zones: the intensification in the South raises the question on the sustainable use of natural resources (soil and water) and the desertion in the North threatens the biodiversity, increase the risk of fire events, and the social life of these highlands. Moreover, we observe important cultural food changes linked to urban expansion and new life conditions, and the increasing demand of "safe" and "ecological" products. These dynamics constitute new opportunities for the agro-ecological systems of the Mediterranean zone with potential pathways for livestock development. If livestock has always played an important role in the valorisation of the resources on these environments, the high competition on animal products at the international level threatens the social and environmental co-viability of these systems and then their future.

Small ruminants are present strongly all-round the Mediterranean countries; with differences between North Mediterranean countries (NMC) and South East countries (SEMC). Northern countries, benefiting from more favourable climate and Common Agricultural Policy, have larger cattle herds, where dry climate and poor rangelands in the south fit more with small ruminants. The region hosts about 5% of the world cattle herd and 13% of the small ruminants. Sheep and goats and its meat production, are important in all Mediterranean countries. Goat is also important in France and Spain for dairy products. Camel herding is important enterprise in the poor pastoral areas and arid areas, as a cheap source of meat. Camels' immigration from sub-Saharan countries to North Africa represents a potential regional trade business.

Pastoral systems are particularly important. NMCs have an average yearly rainfall above 500 mm, where it is below that in SEMCs and even below 300 mm in North Africa with large arid areas. Lack of rainfall is also combined with high temperatures, exacerbating aridity. With the dry climate and consequently lack of ranges, pastoral systems are widespread in the Mediterranean, animals are forced to move to feed in semi-arid regions.

Animal health, with the fragility of the Mediterranean ecosystem, concentrations of human and animal populations, the proximity of humans and animals, difficulties in implementing effective health inspections, and the effect of climate change, are factors that favour the persistence of pandemic animal diseases, the resurgence of epidemics and the emergence of new pathogens. It constitutes a major constraint on husbandry and economic practices in livestock production systems in the region.

Climate changes and associated risks for animal health need to be addressed. Dealing with increasing risks will depend on the efforts to adapt livestock systems. Issues as animal breeding for robustness, adaptation to heat and other extreme conditions, and breeding for higher production under changing abiotic stress should be taken into consideration. Changes in animal production may affect the release of greenhouse gases and therefore interact with mitigation efforts.

Utilization and management of natural resources by bovine and ovine sectors are important for Mediterranean countries. Bovine production is in competition with other agricultural and non-agricultural uses in the Mediterranean, for natural resources as land and water; they are more and more constrained by climate change context as well as by human health, animal welfare and environ-

mental legislations. Sustained research and innovation efforts on animal nutrition, health and breeding as well as on consumers' preferences will contribute to improve bovine production in the Mediterranean and will as adaptation to the ongoing changing in the socioeconomic issues (population, urbanization, etc.) and the growing concern for human health and environmental protection.

Mediterranean dairy and meat sectors experienced changes in recent years. Dairy sector is a strategic socio economic sector in Mediterranean countries. The recent changes in consumption habits of return to traditional and local products, incentivize the development of new forms of traditional dairy products. One of the main challenges is to support this changes as part of the cultural, economic and environmental sustainability of the territories. Dairy manufacturing in NMC are dedicated to cheese processing with high added-value products. Meanwhile, family dairy processing is important activity for rural communities, both for their livelihood and as an important nutritional source. The trade of ovine meat, experienced important changes over the last decade: traditionally south countries were the main suppliers of north countries, but progressively, fluxes have developed from the North to the South and between southern countries.

Box 2. Research challenges on livestock Systems in the Mediterranean (adapted from ARIMNet 2 ISRA, 2016)

Livestock farming systems need to adapt to the multiple and complex changes occurred and will occur in the region. An important issue is that livestock management has been separated in some countries, from cropping activities with the subsequent negative impacts on water and nutrient cycles and ecosystem services.

Efforts are required to encourage integration of crop-livestock systems for more appropriate land use of diversified ecosystems; valorisation of manure, labor, diversification of the products at the farm in relation to the growing demography, pressure on land, and increasing competition.

The main research challenges perspectives are:

1) Identifying efficient crop-livestock systems capable of better utilization of water, soil, rangelands, forages and crop residues, i.e. enhance resource efficiency, and increase the production to meet the rising demand for safe animal products (towards greater socio-economic efficiency);
2) Assessing adaptive capacity, vulnerability and flexibility in the face of current stresses and changes;
3) Assessing socio-ecological, co-viability and resilience with regard to demographic growth, in a historical perspective;
4) Developing future scenarios and priorities for livestock development in the Mediterranean context to increase their capabilities.

IV – How the projects funded by ARIMnet and ARIMNet2 contributed to address these challenges?

Considering that the Mediterranean livestock farming systems need to adapt with multiple and complex changes in the past and present history of the zone, the overall objective of the **CLIMED** project aimed to assess technical, economic and socio-ecological viability of crop-livestock systems in the Mediterranean context. The goal was to help farmers, local communities, researchers and decision makers in thinking future planning for Mediterranean livestock and design priorities, rules,

policies that could better deal with the socio-environmental issues in link with demographic and land pressure, increasing demand and strong high international competition. The potential sustainable intensification processes are generally complex depending both on exogenous opportunities and on endogenous capacities and representations. The CLIMED teams assume that the mixed farming systems, as livelihood strategy, and the integration of livestock and crops, to improve economic and environmental efficiency through recycling, are possible options for sustainable intensification of farming systems. Surveys and monitoring at farm level were conducted to assess various efficiencies. Interviews of actors, mobilization of databases and previous studies were performed to analyse the dynamics of systems in the last decades and to assess their adaptive capacities. Finally, a transversal analysis enables to identify five archetypical farming systems at Mediterranean scale and to perform a qualitative assessment, from quantitative results obtained in the three countries (Alary *et al*., 2019) and Fig. 3 below:

1) The crop specialized system: specialization in high-value crops in the favourable zones, mainly irrigated zones. This specialization is largely driven by the research of labour productivity and social valorisation in link with the educational level or aspirations in terms of living conditions. This specialization extends in all the plains of the coastal line in south of France and Morocco and in the recent New Reclaimed Land (NRL) in Egypt. It has also been encouraged by regional and national policies of rural development in France and in Morocco based on irrigation development and agrarian reform in Egypt in favour of graduates and private entrepreneurs.
2) The dairy specialized system: observed in the favourable zones of Morocco and Egypt (Srairi *et al*., 2014). This specialization concerns mainly large dairy farms that have been driven – and sometimes structured- by the milk agro-industrial sector.
3) The mixed crop-livestock systems: the majority of farming systems in the NRL (Alary *et al.,* 2020, Alary *et al*., 2018) and in the irrigated zone of Morocco, it is no longer present in the south of France, limited in the interstice between the plains and the mountains.
4) The mixed livestock-crop systems: the majority of integrated systems in the rainfed zone, also called agro-pastoral systems due to the maintenance of short seasonal mobility during the favourable climatic years (Osman *et al.,* 2014).
5) The meat specialized systems in vulnerable zones like the mountains in France or the arid and semi-arid zones in Morocco or Egypt, based on the capacity to increase the resource access by the mobility thanks to an extended social network (Alary *et al.,* 2016).

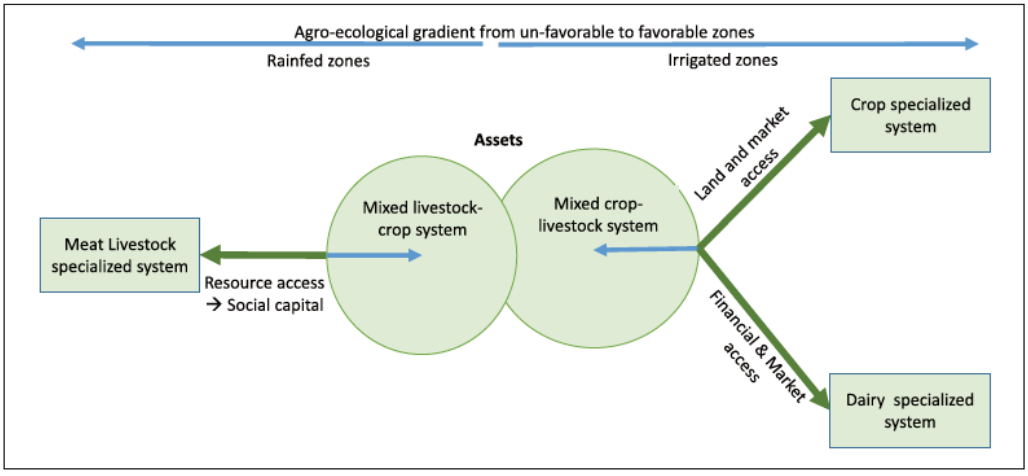

Fig. 3. Specialized vs Diversified Crop-Livestock systems (from Alary *et al.,* 2019).

They identified two main trends within these five archetypical systems: a centrifugal trend of specialization, toward cash crop or dairy herd in favourable areas, and pastoral meat system in harsher environment, and a centripetal trend of diversification, maintaining mixed crop-livestock systems in irrigated areas and agro-pastoral livestock-crop systems and in intermediate rain fed areas. Specialization trend is very strong in France and diversification the most developed in Egypt and Morocco. Those trends may lead to a territorial specialization. The issues of crop-livestock integration had then to be addressed at farm scale for mixed systems, considering the relations between a diversity of farms co-existing in a local territory and the relations between specialized territories. The mobility of the flocks is the mean to organise those relationships. The mixed crop-livestock systems exhibited: (i) a good environmental efficiency, recycling the biomass between activities, (ii) a good economic robustness because of the combination of activities and the security net through social network, but (iii) low labour productivity and incomes, due to a weak access to land and water, to the amount of routine work requirement for integration practices and low empowerment through collective actions. The reproduction of this mixed system is endangered, because of low incomes and the poor social consideration. In another hand, the institutions, through policies and planned infrastructure programmes, have mainly supported the specialized systems that exhibited limits in terms of socio-ecological viability, as dairy farming for instance. Actually, despite the importance to improve the whole dairy chain in Mediterranean countries, a lack of clear information on dairy farmers, collector and processors, milk quality and safety, sales in the region mainly in North Africa limits the stakeholders and deciders to make changes in the sector.

Thus, the **Project "Characterization of Dairy Chain in Mediterranean Countries and Adoption of Optimum Technologies to Improve Dairy Value Chain"** (CDCMCT) aims to identify the different strategies, by characterizing the dairy farms, and evaluating the quality and safety of raw milk they produce, in Algeria, Greece and Egypt to develop dairy sector (see the paper published in this special issue of *Options Méditerranéennes*). In the three countries, most farms are small scales, and dairy farmers produce many traditional dairy products for their families, except for cow dairy farmers who are selling all the milk within a more or less integrated system. Sheep-goat milk quality is good, likewise cow milk physicochemical parameters are within the recommended values in all milk samples collected in Algeria, Greece and Egypt, however the protein and fat contents can't satisfy the dairy processors demand of high quality. In Egypt, buffalo milk, which is very nutritive, is very commonly consumed. Mastitis seems to be one of the major issue that farmers have to face in Algeria and Egypt, probably due to poor hygienic practices. The project team makes thus some recommendations to provide guideline of good practices for Algerian and Egyptian farmers to limit the mastitis in the farms and to initiate new actions for improving milk quantity, quality and safety, as genetic selection and hydroponic fodder production.

Main issues of CLIMED research –as developed in (Alary *et al*., 2019)– pinpointed necessity in: i) overwhelming antagonism between social vulnerability and ecological efficiency of mixed crop livestock farming systems through dedicated rural development policies; ii) limiting micro-regional specialisation processes through the maintaining of a diversity of systems, developing for instance opportunities in promoting territorial food projects and environmental rules reintroducing diversity in cropland occupation; iii) taking advantage of spatial mobility abilities of livestock farming in the Mediterranean to reinforce crop – livestock integration at regional level, promoting collective actions allowing a wider range of livestock farmers of hinterlands to participate, limiting so these efficiency loss and reinforcing sustainability for most vulnerable livestock farmers.

Until recent years, in the Mediterranean, local breeds were considered to be of low productivity and they were largely ignored. The improvement of the livestock sector efficiency was achieved through the use of imported breeds, that were raised either directly in the farms or by crossing with local breeds. It is only recently that the advantages of local breeds in terms of robustness, capacity to valorise local feed resources and to adapt to climate change have been highlighted. As a result,

the questions of their performance, through identification of breeds traits of interests and improvement of the management of livestock systems based on local breeds have arisen, as well as that of the valorisation of their specific productions.

Several projects supported by ARIMNet (**Domestic, Perform, Bovisol**) addressed these issues through different aspects. They share the objective of producing comprehensive approaches of the functioning of the livestock systems linking the farm level, the socio-technical systems and the value chains of the products.

First, the link between the local breeds characteristics and the farming systems management is studied in the perspective of assessing and improving the sustainability of the livestock systems based on local genetic resources.

As part of the **DOMESTIC** project, Araba and Boughalmi (2016) compared three sheep production systems in the Eastern Middle Atlas of Morocco i.e. agro-silvo-pastoral, pastoral and oasis systems through a multicriteria assessment method. They showed that the farms belonging to the two extensive farming systems i.e. agro-silvo-pastoral and pastoral presented better overall sustainability scores than the oasis farms. In these extensive farming systems, local breeds (Timahdite and Beni Guil) and a high vegetation diversity including pastoral species are observed, whereas in the oasis farms the sheep population is less diversified and mainly issued from informal crossbreeding.

The challenges for local breed management in the Mediterranean have been largely studied, in the **DOMESTIC** and **PERFORM** projects. In the **PERFORM** project, it has been showed (Perucho *et al*., 2019a) that in this region where informal crossbreeding with highly productive breeds was widely practiced, a diversity of breeding strategies involving local purebred and crossbred flocks coexist. In the case of the local pure breed, the Karagouniko breed, breeding males are obtained from an exchange between farms among flocks under milk recording scheme. Traditionally associated with grazing on native grasslands, the farming of Karagouniko breed suffered from the decline in the quality of collective rangelands. Dairy policies have encouraged intensification at the expense of traditional practices (earlier lambing period or earlier weaning age). One characteristic of the Karagouniko breed is its resilience in face of climate change, as shown by Karatzia *et al.* (in this issue), with ewes' welfare indices remaining within desirable levels in a context of extreme severe heat stress conditions.

In the **PERFORM** project, the link between breed characteristics and farming practices is further explored. Farmers' preferences for animal trait is analysed to identify how breeding objectives fit farmers' expectations in terms of breeds traits of interests (Perucho *et al.,* 2019 b). Detailed results for the different regions studied (Corsica and Thessaly) should help better define priorities for breeding objectives in local breeding schemes.

Even if most of the research activities on local breeds funded by ARIMNet concern sheep or goats, the **BOVISOL** project focuses bovine cattle farms. Its objective is to find solutions to make the traditional farming systems based on local breeds more productive, competitive and sustainable. in the three countries studied (Algeria, Tunisia, Greece) the local bovine breeds' populations face similar problems such decline, inefficient breeding schemes and unfavorable rearing conditions. In the same time, they are still largely used in traditional extensive family farms, that share similar characteristics in terms of flock management (mixed herds with free grazing and complementary feed in the winter, reproduction through natural mating). A paper presented this special issue of *Options Méditerranéennes* (Tsiokos *et al.)* analyses the characteristics of 318 farms of the three countries and the motivations of farmers for choosing a breed.

Camel farming still plays a marginal role worldwide. However, camel farming plays a central role in the preservation of rural societies, in the development of natural resources in desert areas through a multifunctional livestock system, and in the management of water scarcity.

The **CARAVAN** project addressed the issue of camel sector in order to better understand herd management and camel production and to improve their performance. It has been shown under Algerian pastoral conditions (Gheressi *et al*., 2020) that in the traditional pastoral management of dromedary herds in south-eastern Algeria, dromedaries show poor reproductive performance. The project identifies the need to improve the training of camel breeders in order to improve the performance of the sector.

The second research question addressed in these projects focused on local breeds is the valorisation of the product and the link between the breed characteristics, the production system and the product qualities.

The **DOMESTIC** project addressed this issue through different aspects. Boughalmi *et al.* (2016) studied the opportunities to create a grass-lamb value chain in the Middle Atlas of Morocco area (They showed that a good adaptation of the local breeds, the quality of feed resources available in large rangelands and local expertise of breeders allow to produce a low cost and high quality lamb. However, they identify several difficulties and obstacles in the value chain organization that hinder the lamb valorisation. They suggest that a better organization of stakeholders should be encouraged and promoted to valorise the product.

The need for a better coordination among actors inside the value chain has also been pointed out as a main factor for improving milk valorisation for the cases of Cyprus sheep and goat milk. Ha djipavlou *et al.* (2020) showed that the factors that affected farmer decision for the choice of a milk market channel were the sheep milk price, the type of contract with buyers (formal or informal), the payment method and the price differentiation according to specific milk quality specifications. They identify that stronger forms of coordination between all the links in the value chain are required.

By comparing the cases of four different countries (France-Corsica, Cyprus, Greece-Ipeiros, Cyprus, Morocco), Lauvie *et al*. (2016) underlined the diversity of stakes for product valorisation that depends on the breed status and the type of product. They showed that ultimately there is little evidence of links between the dynamics of breed management and the dynamic of product valorisation.

V – Conclusion

If we compare the results obtained in the ARIMNet-funded research projects with the strategic challenges identified in the ARIMNet strategic agenda (Box 2), we can see that the various research projects funded have produced knowledge on the various questions raised on the efficiency of cereal-livestock systems, the adaptive capacity of diverse livestock systems, their vulnerability and resilience. Three conclusions can be drawn.

The first concerns the association of animal and crop production in mixed crop-livestock systems. This association is identified today as a major pillar of agro-ecology. This is even more relevant in the Mediterranean area, due to the vulnerability of ecosystems and the characteristics of natural resources. The work carried out in the various projects has shown that there are real opportunities to make this association a success through the implementation of appropriate policies and collective actions. Secondly, the projects have shown the limitations and vulnerability of intensive dairy systems based on imported breeds and feed. The difficulties faced by farmers in these specialized systems are numerous. Finally, several projects identified livestock production based on local breeds as a perspective to be developed, as local breeds have the capacity to valorise fodder resources and to cope with climatic conditions as well as the diversity of food habits and diets within the Mediterranean area. These livestock systems, which have certain advantages in terms of resilience and adaptability, will only be able to develop if the specific products they produce are characterized and valued by the market for their specific characteristics. Adequate public policies and coordination of value chain stakeholders are needed to enable this recognition and development of these farming systems.

Acknowledgments

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Sociological profile of touristic camel rides users: a tool to contribute to the sustainable use of native camel genetic resources

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Abstract. Scholars have remarked the opportunities that animal-based tourism provides as the channel to boost local communities' economy and progress while promoting nature conservation efforts. Consumer characteristics and value creation in camel riding tours' target audience are however underdealt topics in literature. Given the survival of certain local camel breeds is contingent on leisure tourism, we examined the sociological and psychographic attributes which may allow differentiating customers. Nonlinear canonical correlation analysis was used to determine profiles of those tourists engaging in these activities to characterize the most profitable segments of camel rides as a business niche. Our results suggest that if not familiarized with camels and their functionalities, travelers may not intentionally engage in camel-based tourism unless offered the opportunity at holiday destinations. On the contrary, amateur users are familiar with camels and valorize the issuing tour operator performance and general comfort during the encounter as pivotal factors conditioning their overall satisfaction. Hence, it is quite recommendable for tour agencies to include this entertaining recreation in packages to individuals, groups and companies, as well as staff to customize the service to make the user feel satisfied and willing to return again. The sustainable use of canary camels as business motors may provide tangible benefits to locals' well-being and natural resources management while these animal genetic resources are protected.

Keywords. Camel-based tourism – Endangered breed – Customer knowledge – Canonical correlation – Nature conservation.

Segmentation de la clientèle touristique de loisir à dos de chameau, comme stratégie marketing pour la conservation à long terme des races menacées

Résumé. *Les chercheurs ont remarqué les opportunités représentées par le tourisme animalier pour stimuler l'économie et favoriser les communautés locales tout en encourageant les efforts de conservation de la nature. Les caractéristiques des clients et la création de valeur pour le public cible des excursions à dos de chameau sont cependant des sujets peu traités dans la littérature. La survie de certaines races locales de chameaux est conditionnée au tourisme de loisir. Nous avons examiné les attributs sociologiques et psychographiques qui peuvent permettre de différencier les clients. Une analyse de corrélation canonique non linéaire a été utilisée pour caractériser les profils des touristes engagés dans ces activités. Nos résultats suggèrent que s'ils ne sont pas familiarisés avec les chameaux et leurs fonctionnalités, les voyageurs ne peuvent pas s'engager intentionnellement dans des activités touristiques ayant recours aux chameaux, à moins que l'opportunité ne leur en soit offerte dans leurs destinations de vacances. Les utilisateurs amateurs connaissent les chameaux et accordent de la valeur aux performances des voyagistes émetteurs et au confort général lors de la rencontre comme des facteurs déterminants conditionnant leur satisfaction globale. Il est recommandé aux agences de voyage d'inclure ce divertissement dans des forfaits destinés aux particuliers, aux groupes et aux entreprises, ainsi qu'au personnel de personnaliser le service pour que l'utilisateur se sente satisfait et disposé à revenir. L'utilisation durable des chameaux canaris comme moteurs d'activités économiques peut apporter des avantages tangibles en termes de bien-être des habitants et de gestion des ressources naturelles, tout en protégeant ces ressources zoogénétiques.*

Mots-clés. *Tourisme à dos de chameau – Race menacée – Connaissance des clients – Corrélation canonique – Conservation de la nature.*

I – Introduction

Tourism, one of the largest and fastest-growing economic activities all over the world, encompasses a wide variety of sectors that offer diverse products and/or services to visitors focusing on customer's satisfaction, safety and enjoyment (Marinao, 2017; Sofronov, 2018). In particular, nature-based tourism or eco-tourism has become the most popular segment of the tourism industry since the contemporary trendiest destinations are changing from traditional mass tourism emplacements to attractive natural environments. That is, a responsible travel to natural areas that led to the generation of revenues for conservation of the environment in which it is based and the socio-economic development of locals (Fennell, 2020). In the particular case of camels, this animal species is well known to be an iconic attraction for trekking experiences, excursions and picture taking in desert places at Middle East, India, Africa and Spain (Seifu *et al*., 2018; Wilson and Gutierrez, 2015; Wilson, 2013). Such interactive encounters not only provide enjoyment for tourist users but also revenues for animal genetic resources' sustainable conservation (Coria and Calfucura, 2012).The present research arises in the context of the CARAVAN project – toward a camel transnational value chain, an ARIMNet2 initiative (ERA-NET ARIMNET2/PCI2016-00011) which has placed the focus on domestic camel revalorization. The purpose of the present investigation is set at the segmentation analysis of this adventure tourism subsector, that still remains overlooked within the scientific literature. Given that some local camel breeds are capitally used for touristic activities, their long-term viability relies on this functional segment (i.e. endangered Canarian camels from Canary Islands, Spain) (Iglesias Pastrana *et al*., 2020). The mentioned breed historically acted as service animals (Schulz, 2008) but was displaced from rural labours by transport means' technification (Iglesias *et al*., 2020). Its total rural census diminished and the breeders decided to start including their animals in tourist rides by the early 1990s (Wilson and Gutierrez, 2015). However, the census of this European unique camel breed is currently estimated on 1000 animals. As a direct consequence, it becomes indispensable to clearly analyse and monitor the profile of the demands of this tourism sector for further exceptional investment attempting to ensure the sustainable conservation of Canarian camels as their main element (Bhandari and Heshmati, 2010; Di Minin *et al*., 2013).

Through deepening market segmentation, tourism companies may identify a mix of sociodemographic, motivational and psychographic variables that are exhibited from consumers who make up a target market and are most likely to purchase for and benefit from their products and services (Díaz *et al*., 2012; Fernández-Hernández *et al*., 2016). Hence, tourism marketers and managers will be proficient in devising tourist development initiatives that can improve the destination competitiveness and loyalty by delivering a high-quality customized experience for tourists and thus generating and increasing revenues for the sustainable management and conservation of the mentioned camel breed, the only genetic resource of such nature along Europe.

II – Research methodology

1. Study sample and geographics

A total number of 131 respondents (55 males and 76 females) participated in this study. Eight Canarian dromedaries (6 males and 2 females; aged between 4 and 32 years) reared for tourist rides in Southwestern Spain constitute the animal sample. The saddle used for riding is the English type.

During the high season in Southern Spain (1st July to 30th September 2019) and thus the business experiments its high demand, we asked all the consumers that enjoyed a camel ride to voluntarily fulfil an on-site Likert-type questionnaire aimed to collect multiple data (socio-demographics, motivational factors, perceived value service and personal attitudes towards camel functionalities) (Iglesias Pastrana *et al*., 2020).

2. Data statistical analysis

A nonlinear canonical correlation analysis was performed using the Optimal scaling routine of the Dimension reduction procedure of IBM SPSS Statistics version 25 (IBM Corp. 2017). The nonlinear canonical correlation analysis, is also known as OVERALS to determine scale dimensionality.

To interpret the dimensions obtained, those variables with component loadings of over |0.5| (Bárcenas *et al*., 2003), were deemed the most effective ones at identifying relationships among sets (Greenacre and Hastie, 1987).

III – Results and discussion

Two dimensions were identified to explain 41.2 % of shared variability in the dataset. Table 1 reports the eigenvalues for the bi-dimensional solution of nonlinear canonical correlation analysis performed.

Table 1. Eigenvalues for the two-dimensional solution of nonlinear canonical correlation analysis

Variable sets	Dimension 1	Dimension 2	FIT
Seasonality and timing	0.505	0.947	1.452
Customer and trip profile	0.400	0.910	1.309
Decision-making motivating factors	0.458	0.564	1.022
Staff performance	0.652	0.401	1.053
Camel behavior	0.676	0.630	1.305
Quality of riding route	0.320	0.458	0.778
Previous experience	0.694	0.738	1.431
Customer impressions	0.471	0.333	0.804
Customer satisfaction and loyalty	0.913	0.521	1.434
Mean	0.565	0.611	1.177
Eigenvalue	0.435	0.389	0.824

Within the frame of market segmentation in tourism research, the maximum number of dimensions selected and their respective eigenvalues when aiming to explain the greatest percentage of variance due to correlation between variable sets at an acceptable loss level (see Table 2; Model partitioning fit and loss analysis), is quite variable among approaches. Multiple study design-related factors such as the sample size, data outliers, normality distribution (Hair Jr Joseph *et al*., 2009), the type of tourism activity being investigated, the number of different variables tested and the rating scale(s) used (Dolnicar, 2008), markedly influence these statistical outputs. In our case, despite the high conceptual heterogeneity within variables/items used as potential segmentation criteria (tourist socio-demographics, staff and camel behavioral performance, and customer attitudes/knowledge towards/on camel-based tourism), the eigenvalues for both dimensions fit the mean range values reported by other authors investigating the relationships between sets of variables that help to explain travel motivations and customer perceived value of tourist services (Oh *et al*., 1995; Pyo *et al*., 1989; Whyte, 2017). Hence, the conclusions derived from the present pioneer research are valid and reliable.

Based on the semantic meaning of the variables with component loadings of over |0.5| within each dimension (Table 3; variables with component loadings of over |0.5| are in bold italics), these last can be labelled as: Dimension 1 or customer knowledge on camel functionalities and involvement in a pleasing camelback riding tour during holidays, and Dimension 2 or staff manners and comfortability during camelback riding for experienced customers satisfaction.

Table 2. Model partitioning fit and loss analysis results

Set	Variables	Multiple Fit			Single Fit			Single Loss		
		Dimension 1	Dimension 2	Sum	Dimension 1	Dimension 2	Sum	Dimension 1	Dimension 2	Sum
Seasonality and timing	Month of Visit	0.349	0.161	0.510	0.349	0.161	0.510	0.000	0.000	0.000
	Year of Visit	1.407	0.263	1.671	1.407	0.263	1.671	0.000	0.000	0.000
Customer and trip profile	Sex	0.024	0.001	0.025	0.024	0.001	0.025	0.000	0.000	0.000
	Age	0.058	0.034	0.092	0.050	0.003	0.053	0.008	0.032	0.039
	Country origin	0.091	0.069	0.160	0.090	0.068	0.158	0.001	0.001	0.002
	Study level	0.229	0.042	0.271	0.227	0.018	0.245	0.002	0.024	0.026
	Travel Companion	0.168	0.009	0.177	0.168	0.000	0.168	0.000	0.009	0.009
Decision-making motivating factors	Camel knowledge	0.047	0.118	0.165	0.001	0.110	0.111	0.046	0.008	0.054
	Environmental knowledge	0.294	0.020	0.314	0.270	0.002	0.272	0.023	0.018	0.042
	Andalusian culture	0.046	0.098	0.144	0.010	0.040	0.049	0.036	0.058	0.094
	Andalusian friends/relatives	0.131	0.019	0.150	0.102	0.002	0.104	0.028	0.017	0.046
	Special event in Andalusia	0.045	0.126	0.171	0.004	0.100	0.104	0.041	0.026	0.067
	Conference/meeting	0.062	0.031	0.093	0.049	0.012	0.060	0.013	0.019	0.033
	Education/research	0.088	0.372	0.459	0.058	0.356	0.415	0.029	0.015	0.045
	Business	0.090	0.069	0.159	0.083	0.051	0.134	0.008	0.018	0.025
	Holidays	0.455	0.026	0.481	0.438	0.009	0.447	0.017	0.017	0.034
Staff performance	Language abilities	0.149	1.144	1.293	0.141	1.142	1.284	0.008	0.001	0.009
	Camel knowledge	0.161	0.025	0.186	0.161	0.024	0.184	0.000	0.001	0.001
	Nature knowledge	0.031	0.015	0.046	0.029	0.012	0.040	0.002	0.004	0.006
	Manners	0.153	0.330	0.484	0.153	0.330	0.483	0.000	0.000	0.001
	Social skills	0.452	0.121	0.573	0.452	0.119	0.570	0.001	0.002	0.003
	Willingness to serve	0.377	0.101	0.479	0.377	0.101	0.479	0.000	0.000	0.000
Camel behaviour	Unfocused/Distracted	0.044	0.094	0.138	0.043	0.093	0.137	0.001	0.000	0.001
	Calm/Awaiting	0.045	0.053	0.098	0.020	0.032	0.052	0.025	0.020	0.045
	Mistrustful	0.093	0.007	0.100	0.092	0.006	0.097	0.001	0.002	0.003
	Fearful	0.000	0.124	0.125	0.000	0.124	0.124	0.000	0.001	0.001
	Depressed	0.009	0.103	0.112	0.006	0.103	0.109	0.002	0.001	0.003
	Curious	0.018	0.082	0.100	0.016	0.062	0.078	0.001	0.020	0.022
	Surprised	0.072	0.016	0.087	0.059	0.008	0.067	0.013	0.007	0.021
	Rejection	0.023	0.094	0.117	0.020	0.093	0.113	0.003	0.001	0.004
	Indifferent/Irresponsive	0.205	0.102	0.307	0.194	0.099	0.293	0.011	0.003	0.014
	Cautious	0.050	0.107	0.157	0.017	0.101	0.118	0.033	0.006	0.039
	Nervous	0.037	0.011	0.049	0.036	0.007	0.043	0.002	0.005	0.006
Quality of riding route	Secure	0.001	0.004	0.005	0.000	0.004	0.004	0.001	0.000	0.001
	Interesting	0.013	0.009	0.022	0.004	0.001	0.005	0.008	0.008	0.016
	Varied	0.010	0.079	0.089	0.002	0.042	0.044	0.008	0.037	0.045
	Appropriately long	0.106	0.015	0.121	0.090	0.000	0.090	0.016	0.015	0.031
	Walk overall quality	0.501	0.022	0.523	0.500	0.005	0.506	0.000	0.017	0.017
Previous experience	Previous experience	0.087	0.128	0.215	0.084	0.126	0.211	0.003	0.002	0.005
	When did previous experience take place?	0.000	0.031	0.032	0.000	0.031	0.032	0.000	0.000	0.000
	Comparison between experiences	0.012	0.156	0.168	0.012	0.155	0.167	0.001	0.000	0.001
	Did you receive previous training before the walk?	0.002	0.086	0.087	0.001	0.086	0.087	0.000	0.000	0.000
	Personal impression	0.008	0.003	0.011	0.008	0.003	0.011	0.000	0.000	0.000

	on involved camels' welfare									
	Do you think this tourism activity has wide impacts on camel health and welfare?	0.425	0.121	0.546	0.235	0.056	0.290	0.190	0.065	0.255
	Personal impression on camel riding as a sustainable tourism activity	0.312	0.149	0.461	0.303	0.131	0.434	0.008	0.019	0.027
	Easiness of camel-back riding	0.070	0.079	0.150	0.070	0.079	0.150	0.000	0.000	0.000
	Comfortability of camel-back riding	0.035	0.388	0.423	0.022	0.387	0.409	0.013	0.001	0.014
	Familiarity towards worldwide camel uses	0.046	0.005	0.051	0.046	0.004	0.050	0.000	0.001	0.001
	What do you think camels are raised for?	0.364	0.074	0.438	0.361	0.019	0.380	0.003	0.055	0.058
	Consciousness about the usefulness for endangered camels breeding and conservation	0.055	0.036	0.091	0.042	0.035	0.078	0.013	0.001	0.013
	Walk length	0.020	0.075	0.094	0.001	0.073	0.073	0.019	0.002	0.021
Customer satisfaction and loyalty	General satisfaction	0.055	0.423	0.478	0.048	0.417	0.465	0.007	0.006	0.012
	Return intention probability	0.052	0.058	0.111	0.036	0.054	0.090	0.016	0.005	0.021

Table 3. Components loadings for nonlinear canonical correlation analysis

Set	Variables	Dimension 1	Dimension 2
Seasonality and timing	Month of Visit	0.477	0.060
	Year of Visit	***-0.655***	-0.152
Customer and trip profile	Sex	0.165	0.005
	Age	-0.322	-0.068
	Country origin	-0.335	-0.260
	Study level	-0.497	-0.145
	Travel Companion	-0.403	-0.004
Decision-making motivating factors	Camel knowledge	-0.062	0.400
	Environmental knowledge	-0.199	0.334
	Andalusian culture	0.024	0.337
	Andalusian friends/relatives	0.174	0.187
	Special event in Andalusia	0.054	0.324
	Conference/meeting	0.105	0.211
	Education/research	0.152	-0.033
	Business	0.090	0.228
	Holidays	***0.533***	0.164
Performance	Language abilities	0.008	***0.576***
	Camel knowledge	-0.131	0.124
	Nature knowledge	-0.177	0.100
	Manners	-0.193	0.028
	Social skills	-0.314	0.103
	Willingness to serve	-0.378	0.135

Camel behaviour	Unfocused/Distracted	-0.239	0.120
	Calm/Awaiting	0.158	-0.147
	Mistrustful	0.099	0.093
	Fearful	-0.041	0.083
	Depressed	-0.059	-0.050
	Curious	0.074	0.198
	Surprised	-0.012	-0.050
	Rejection	-0.123	-0.117
	Indifferent/Irresponsive	-0.392	-0.230
	Cautious	0.093	-0.261
	Nervous	-0.042	0.127
Quality of riding route	Secure	-0.012	-0.031
	Interesting	-0.003	-0.065
	Varied	-0.117	0.349
	Appropriately long	-0.365	0.124
	Walk overall quality	***0.692***	0.090
Previous experience	Previous experience	-0.218	0.348
	When did previous experience take place?	-0.058	-0.124
	Comparison between experiences	-0.216	***0.511***
	Did you receive previous training before the walk?	0.016	0.379
Customer impressions	Personal impression on involved camels' welfare	-0.067	-0.034
	Do you think this tourism activity has wide impacts on camel health and welfare?	-0.235	-0.392
	Personal impression on camel riding as a sustainable tourism activity	-0.338	0.465
	Easiness of camel-back riding	-0.258	0.426
	Comfortability of camel-back riding	-0.206	***0.674***
	Familiarity towards worldwide camel uses	0.214	-0.098
	What do you think camels are raised for?	***-0.586***	-0.176
	Consciousness about the usefulness for endangered camels breeding and conservation	0.162	0.152
	Walk length	-0.050	0.300
Customer satisfaction and loyalty	General satisfaction	-0.225	***0.653***
	Return intention probability	0.196	-0.251

Given the popularization in recent times of nature-based leisure tourism and the increased public awareness on natural resources sustainable conservation, involved stakeholders and marketing agencies have started to promote interactive encounters in which tourists can get in close contact with domestic animals or observing wild species on their natural habitat under tightly controlled conditions (Bertella, 2014; Moorhouse *et al*., 2015). Domestic equids, camels, elephants or marine mammals and wild endangered animals are the leading ambassadors and attractions in this recreation industry (Markwell, 2015). Such innovative products provide tourists with unique experiences and enrich their cultural understanding of the world natural resources (Stone, 2015).

In the particular case of camels, attention provided to customers, specially linked to the communication skills of staff may play an important role. However, our results suggest selection for those animals whose gaits, morphology or behaviour may translate in easier and smoother rides are equally valuable and worth being considered as their repercussion on overall satisfaction may equal that reported for the attention to customers (Dimension 2; Table 3), but also may denote better animal welfare-promoting practices being implemented. By understanding the target customers' de-

mands and expectations, breeding programmes aimed at accurate selection of riding camels for functional traits of interest will enhance the long-term sustainable use of these animal resources and its cultural, historical value. Notwithstanding, in a domestic scenario, the familiarity of customers towards the functionalities of a species (Dimension 1; Table 3) or breed widely affects the likelihood for them to get involved in activities that motivate active interaction with animals and that can be sometimes the main niche for their survival in local regions. That is the case of the camels, a species well known for inhabiting desert areas mainly in Africa and participate in caravan tours. However, an endangered camel breed is distributed along the Canarian archipelago and southern areas of the Iberian Peninsula (Spain) but the level of consciousness of the general public about the existence and thus the functionality (tourism sector) of this local breed still remains low. In turn, camel-back riding appears not to be a preference for local consumers when planning their holidays but include this recreation once they are in the destination and may get informed about the chance to join this experience (Iglesias Pastrana *et al*., 2020). Strongly related to this condition and if finally book for this type of interactive encounter, unfamiliarized users could feel mistrustful when approaching camels and therefore affect animal behavior and tour overall quality.

On the other hand, travelers that are familiarized with camel functionalities and actively seek for being engaged in these camel-human leisure interactions, are supposed to be more critic when evaluating all the surrounding elements that affect the satisfactory development of the ride tour. At the time they demand to satisfy a combination of social, recreational and emotional needs, they may be willing to give feedback to the destination through cultural and/or monetary exchange only within a framework of a corporative defined social responsibility and ethics in the tour operator supply chain. In this context, staff performance and general comfortability perceived by the riders during the tour, are intrinsic factors affecting the experiential consumption in this tourism brand.

IV – Conclusions

Within this holistic market, business groups have to be aware that more than one target market can appear on the scene: a primary or main target market and a secondary one less large but growthness potent. Experienced users in this tourism brand find the activity memorable when the emotional binding with the surrounding elements during the encounter and the staff enrolling into service performance create an experience-like quality. Contrastingly, novel customers, mainly unfamiliarized with camels and their participation in tourist activities, put in evidence the need for scholars and tourism stakeholders to promote community-wide awareness programs and adapted touristic packs, respectively. Basing on this customer knowledge, high-quality leads can be effectively converted into paying customers by homing in on product's promotion specific efforts. Camel functional selection may promote the enhancement of the touristic activities in which camels may participate, promoting customer comfortability at the same time that animal welfare is preserved. In turn, such customized services will allow to generate resources for the sustainable management and conservation of camel genetics resources at long term.

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Some strategies proposed in three Mediterranean countries to develop dairy sector

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Abstract. The present paper presents the different strategies followed in three Mediterranean countries (Algeria, Greece and Egypt) to develop dairy sector, namely characterization of dairy farms and assessment of milk quality and safety. The research activities were conducted on dairy cattle sector in Algeria, Northern Greece and Egypt, while sheep-goat sector was studied in Northwest Greece. Farmers were interviewed about some hygiene practices, animal health, involvement of woman and traditional dairy products produced on the farms. Raw milk samples were also collected and analyzed for basic physicochemical and microbiological variables. Results revealed that Greek farmers respect hygienic practices better than Algerians and Egyptians; therefore, mastitis is not the most observed disease in the Greek farms compared to Algerian and Egyptian farms. Few women were involved in the work at farms. In the three countries, many traditional dairy products were produced on the farms for their own consumption, except for dairy cow farmers in Greece who prefer to sell all the milk. Sheep-goat milk quality is good, likewise cow milk physicochemical parameters collected in all the three countries were within the recommended values, but they cannot satisfy the high protein and fat contents demanded by the processors. It is necessary to provide guidelines of good practices for Algerian and Egyptian farmers to limit the mastitis in the farms. Also, new technologies should be introduced in Mediterranean countries to improve milk quantity and quality.

Keywords. Mediterranean countries – Milk quality – Safety – Hygiene practices.

Rapport sur les stratégies suivies dans les pays méditerranéens pour développer le secteur laitier

Résumé. *Le présent rapport présente les différentes stratégies suivies dans trois pays méditerranéens (Algérie, Grèce et Égypte) pour développer le secteur laitier, à savoir la caractérisation des exploitations laitières et l´évaluation de la qualité et de la sécurité du lait. Les activités de recherche ont été menées sur le secteur des bovins laitiers en Algérie, dans le nord de la Grèce et en Égypte, tandis que le secteur ovin-caprin a été étudié au nord-ouest de la Grèce. Les fermiers ont été interrogés sur certaines pratiques d'hygiène, la santé animale, l'implication de la femme et les produits laitiers traditionnels produits dans les fermes. De plus, des échantillons de lait cru ont été collectés et analysés pour des variables physico- chimiques et microbiologiques basiques. Les résultats ont révélé que les fermiers Grecs respectent mieux les pratiques d'hygiène que les Algériens et les Egyptiens ; par conséquent, les mammites sont moins fréquentes dans les fermes Grecques comparativement aux fermes de l'Algérie et de l'Égypte. Peu de femmes étaient impliquées dans le travail de la ferme. Dans les trois pays, de nombreux produits laitiers traditionnels étaient produits dans les fermes pour leur propre consommation, à l'exception des éleveurs de vaches laitières en Grèce qui préfèrent vendre tout leur lait. La qualité du lait de brebis et de chèvre est bonne, de même que les paramètres physico-chimiques du lait de vache collectés dans les trois pays qui se situaient dans les valeurs recommandées ; mais le lait ne*

satisfait pas les demandes des transformateurs en termes de teneurs en protéine et en matières grasses. Il est nécessaire de fournir un guide de bonnes pratiques aux éleveurs Algériens et Egyptiens pour limiter les mammites dans les exploitations. Aussi, les nouvelles technologies devraient être introduites dans les pays méditerranéens pour améliorer la quantité et la qualité du lait.

Mots-clés. *Pays Méditerranéens – Qualité de lait – Sanitaire – Pratiques d'hygiène.*

I – Introduction

Growth in world milk production is projected to increase by 22% by 2027. Dairy demand in developed countries has been shifting for several years towards butter and dairy fat (OECD and FAO, 2018). The dairy sector is still among the most fundamentally sector in Mediterranean countries as it participates to promote food security, stimulate rural economic development and ensure employment through the whole dairy chain in the region. In Greece, the dairy industry is one of the most important and developed industries. It represents about 7% of the total food industry (winery, brewery, etc) with about 32% of the food industry turnover (Chasapis and Christodoulaki, 2007-2010). However, milk and dairy products are among the main ingredients imported for processing (Faniadis, 2020). Algeria was the third largest dairy importing country in 2018 after China and Mexico despite the government aims to reduce dairy imports; milk drinks made from reconstituted milk powders dominate the country's dairy consumption, making Algeria a significant market for whole milk powder and skim milk powder (Hoogwegt Group, 2018). Likewise, in Egypt, domestic production meets only 72 % of Egypt's demand. In order to fill the gap between the demand and supply of good quality milk, dairy processors and retail channels tend to rely on imports of milk powder and other dairy products (ILO, 2020). Also, it is one among the main importers of butter and it is expected to more than double their imports of cheese by 2027 (OECD and FAO, 2018).

In fact, high milk quality production encourages the dairy industries to produce a wide variety of dairy products. It seems that dairy consumption is associated with a decreased prevalence of metabolic related disorders (McGregor and Poppitt, 2013). However, Algeria, Greece and Egypt are facing many challenges to produce more milk with better quality and safety in the future to meet the demand of dairy processors and ensure food security. In addition, it is important that developing countries invest in the new technologies to set up a strong plan to improve dairy genetic instead of continuing to import dairy cows and powdered milk and dairy products to cover its needs.

Despite the importance to improve the whole dairy chain in Mediterranean countries, a lack of clear information on dairy farmers, collectors and processors, milk quality and safety, and sales and commerce in the region, mainly in North Africa, limits the stakeholders and decissors ability to make changes in the sector.

However, for identifying the different gaps that constraint dairy chain in Mediterranean countries and in order to suggest interventions to overcome these barriers and implement new ideas, many actions were conducted and ongoing under the ERA-NET ARIMNet2-2017 Project "Characterization of Dairy Chain in Mediterranean Countries and Adoption of Optimum Technologies to Improve Dairy Value Chain".The consortium of the present project is composed of 4 partners (Algeria, France, Egypt and Greece), and one collaborator (Spain). The work plan of the project is divided into 3 work packages (WPs), WP1: Analysis of dairy chain in Mediterranean countries, WP2: Assessment of milk and dairy products quality and safety along dairy chain and WP3: Introducing and testing new technologies in North Africa to improve milk quality and preservation. This article deals with the work carried out on dairy cattle in Algeria and Egypt, and on dairy cattle, sheep and goat in Greece. Our activities aim to suggest strategies to characterize firstly the dairy farms and secondly to evaluate the quality and safety of raw milk to develop the dairy sector in three Mediterranean countries, Algeria, Greece and Egypt.

II – Material and methods

1. Areas of study

The present studies were carried in Algeria, Greece and Egypt.

In Algeria, the research activities were held on dairy cow farms in the wilaya of Setif (North East, Algeria); Setif is a semi-arid region, characterized by a subtropical climate with hot summers and cold to mild winters where the breeders prefer to raise Montbeliarde and Fleckvieh cows than the Holstein breed because of their adaptability to the difficult conditions of the region. The wilaya of Setif is a major dairy basin with an annual milk production of around 300 million liters of milk, which corresponds to 11.5% of national production, so it is the first milk producer Wilaya in Algeria (Dechambre, 2018).

In Greece, research activities were conducted in 2 regions, in the regional unit of Ioannina (Epirus, Northwest part of Greece) on dairy sheep and goat farms and in central Macedonia (Northern Greece) on dairy cow farms.

In the region of Ioannina, the local goat breed (Greek Goat) (*Capra prisca*) consists the major part of the population with good adaptation to the environmental conditions. Also mixed breeds existed in the majority of sheep farms. Although there were some farms with purebred animals of the local sheep breeds of Katsika (Karamaniko) and Kalaritiko. In central Macedonia, the most common breed of dairy cows raised is Holstein. In 2020, the annual milk production in central Macedonia represents more than half (51.59%) of the national production of cow's milk in Greece (ELGO-Dimitra, 2021).

In Egypt, the research activities were conducted in11 dairy farms, 8 small farms located in Behara and 3 commercial farms located on Behara,Faum and Sharkia governorates. Milk samples were collected from Giza, Benisuef and Alexandria gouvernorats.

2. Questionnaires survey

For analyzing the dairy chain in Algeria, Greece and Egypt, many questionnaires have been designed to collect information from farmers (feed management, animal health, practices handled for milking and storage), milk collectors (milk quantities collected, tools used to assess milk quality, milk storage condition and transport, cleaning and disinfection of tanks and all dairy equipment) and dairy processors (milk handling and selling practices dairy products produced such as milk, cheeses or other products using milk).

Data were obtained through interviews of individual farmers by visiting 50 farms in Algeria, 40 in Northern Greece and 11 in Egypt. In the sheep and goat survey, 52 farms participated as described by Pappa *et al*. (2021).

In the present paper, only the aspects mentioned below are reporting. However, the present article focuses in providing an overview on the characteristics and management of visited dairy farms in the three countries are presented, while the other data gathered are still being analyzed. Dairy cattle farms were categorized in Algeria and Egypt as small (<10 cows), medium (10-20 cows) or large scale(20 cows); while in Greece, dairy cattle farms could be small (<50 cows), medium (50-100 cows) and large scale (>100 cows). Disease and animal health problems that concern dairy farms as mastitis, low fertility or others (lameness cow, digestion…) in each country were assessed; hand washing by farmers before milking were noted by Yes /No. Change of the litter observed in the farms is classified into 3 categories: frequent/ when it gets wet / rare. Also, when the woman is involved in farm work, her engagement is classified into 3 levels: full / partial / low level of activity. In addition, farmers were asked about the traditional dairy products produced on the farms for their own consumption as cheese, butter, or other dairy products: (leben, raib-acidified milk, yoghurt, etc).

3. Analysis of milk quality and safety

Milk samples collection, microbiological content and physicochemical parameters analyzed in raw cow milk and sheep and goat milk samples in Algeria and Northwest Greece respectively were detailed in recent published papers (Allouche *et al*., 2021; Pappa *et al*., 2021).

In Northern Greece, cow milk samples were collected from 40 farms in the regional units of central Macedonia (Northern Greece); physicochemical analysis was performed using MilkoScan FT1-FOSS analytical, while in Egypt, buffalo and cow milk samples were collected from 9 and 39 milk shops respectively from Giza, Benisuef and Alexandria gouvernorats, and analyzed for physicochemical parameters using Lactoscan, Ultrasonic milk analyzer (Stara Zagora, Bulgaria).

III – Results and discussion

1. Farm characteristics and management

Table 1 shows the characteristics and management of dairy farms in Algeria, Greece and Egypt, animal health problems, involvement of woman and dairy products produced on the farms.

Table 1. Dairy farm characteristics and management in Algeria, Greece and Egypt

		Algeria (Sétif; cattle farms) n = 50	Northwest Greece (Loannina region; sheep and goats farms) n = 52	Northern Greece (Central Macedonia; cattle farms) n = 40	Egypt (Behara, Faum and Sharkia governrates; cattle farms) n = 11
Farm scale	– Small scale	+	+		+
	– Medium scale		+	+	
	– Large scale		+		
Most observed animal health problems	– Mastitis	+			+
	– Fertility			+	
	– Others		+		
Hand washing before milking	– Yes		+	+	+
	– No	+			
Change of animal litter	– Frequently		+	+	+
	– When the litter is wet	+			
	– Rarely				
Involvement of the woman in the farm wok	– All activities	+	+		+
	– Partial activities	+		+	+
	– Few activities				
Traditional dairy products produced on the farms	– Butter	+		No product	+
	– Cheese	+	+	+	
	– Other products	+	+		+

n: number of visited farms.

In Algeria and Egypt, most visited dairy cattle farms were small scale, while they were medium scale in Northern Greece and in Northwest Greece, sheep and goat farms were small, medium or large scale. In fact, the number of animals raised in the farms depends on several factors such as farm surface, availability of natural fodder, feed price, milk purchase request and selling milk price, and the capacity of the farmers to recruit additional employees.

In Greece, farmers wash their hands and change frequently the animal litter, which explains the few cases of observed mastitis in dairy sheep-goat and cattle farms. Controversy, mastitis is the first health problem observed in Algeria where many farmers neglect hand washing before milking and the litter was not changed frequently. Likewise, mastitis is the first disease observed in the Egyptian dairy farms despite the fact that many farmers wash their hands before milking due to the lack of other hygiene farm practices.

Mastitis is an inflammation of the udder usually caused by bacterial infection and it is common in dairy herds causing important economic losses. It cannot be eradicated but can be reduced to low levels by good management of dairy cows. Many factors influence the frequency of mastitis infection and management is particularly important (Akam *et al*., 1989). In fact, maintaining the sanitary condition of the barn is important for the production of good quality milk. Clean, dry and comfortable bedding condition is important to minimize the growth of pathogenic microorganisms (Gurmessa, 2015).

In the present report, analysis of dairy farmers allows us to identify the different gaps that constraint milk production in term of quantity, quality and safety to suggest an effective solution for each Mediterranean country. In fact, addressing weaknesses and gaps in post-production activities like milk handling, collection, storage and transportation is of equal importance to maintain and put forward the value-added during production phase (ILO, 2020). Therefore, it is important to make Algerian and Egyptian farmers aware about the importance of hygiene practices in order to reduce mastitis, and consequently reduce the loss of milk and use of antibiotics. It is urgent to provide them a clear and practical guide in Arabic language about the good hygiene practices in the farm. The guide could be distributed through the dairy cooperatives/associations and processors.

Since a long time, women have always helped her families in most of the work on farms in many rural communities in the word. From the results of the present studies held in the three Mediterranean countries, farmers were male in most of the cases; only 3 women were registered as owners of farms (7.5%) in the 40 dairy farms visited in central Macedonia (Northern Greece), although when inquiring the farmers on the staff employed on farm, 24 farm owners (60%) referred to their wives and/or daughters as members of the skilled personnel working on-farm. However, in the three countries, when women are involved in the farm work, often fulfill diverse roles on-farm, from calf feeding to milking cows, to help and assist their families by making many efforts and sacrifices. In Greece, women played a very important family role and showed a high sense of responsibility in making important decisions inside the family context. In most of the cases women were dedicated to their families and were transmitting the cultural traditions to the following generations. In Egypt, women used the surplus of milk production to make butter or cheese (Karish or Mesh) for home consumption or sale (neighbours or local markets) (Daburon *et al*., 2016).

Regarding the production of dairy products on the farms, it seems that Algerian and Egyptian farmers produce butter, cheese, *leben* or *raieb* (acidified milk) for their own consumption. Nevertheless, Greek farmers who raise cattle sales all the milk without producing any product, while Greek farmers who raise sheep and/or goats produces cheese or yoghurts for their families. From these observations, it is clear the importance to produce good milk quality as it will not be only sold with high price to the processors but also participates to the nutrition and promotes food security and health for the rural communities.

2. Assessment of milk quality and safety

Physicochemical parameters and microbiological content analyzed in raw cow milk, sheep and goat milk were detailed in the recent published studies by Allouche *et al*. (2021) and Pappa *et al*. (2021). Milk physicochemical parameters analyzed in Northern Greece and Greek national cow milk samples in 2020 are presented in Table 2: while physicochemical analysis of buffalo and cow milk samples collected in Egypt from shops are shown in Table 3.

Table 2. Physicochemical parameters of cow milk samples collected in central Macedonia (Northern Greece) and national reference laboratories[1]

	Cow milk samples collected from 40 farmers in Central Macedonia (Northern Greece)			Greek cow milk samples collected from national reference laboratories[1]
Parameters	**Mean ± SE**	**Minimum value**	**Maximum value**	**Mean ± SE**
Fat, %	3.915 ± 0.0200	3.48	4.34	3.905 ± 0.0102
Protein, %	3.327 ± 0.0060	3.19	3.44	3.320 ± 0.0038
Lactose, %	4.824 ± 0.0090	4.72	4.98	4.772 ± 0.0046
Solid in non-fat substance, %	8.835 ± 0.0101	8.66	9.02	8.808 ± 0.0072
Freezing point depression, °C	-0.5261 ± 0.0002	-0.523	-0.530	-0.5254 ± 0.0001
Colony forming units, CFU/ml x 1000	51.92 ± 2.383	15.5	99.5	64.11 ± 2.931
Somatic cell count, SCC/ml x 1000	384.048 ± 17.2815	128.7	723.4	333.289 ± 7.6255

[1]ELGO-Dimitra (2021).

Table 3. Physicochemical parameters of Buffalo and cow milk samples collected from milk shops in Egypt

	Buffalo milk samples collected from milk shops (n = 39)			Cow milk samples collected from milk shops (n = 9)		
Parameters	**Mean ± SE**	**Minimum value**	**Maximum value**	**Mean ± SE**	**Minimum value**	**Maximum value**
Fat, %	6 ± 0.22	2.9	7.8	3.8 ± 0.23	2.33	4.94
Protein, %	3.8 ± 0.37	2.6	4.7	3.2 ± 0.12	2.68	3.73
Lactose, %	5.7 ± 0.13	3.9	7.1	4.8 ± 0.18	4.03	5.60
Solid in non-fat substance, %	10.3 ± 0.16	7	12.9	8.7 ± 0.32	7.33	10.20
Freezing point depression, °C	-0.7 ± 0.3	-0.8	0	-0.6 ± 0.02	-0.67	-0.45
Density	32.1 ± 3.03	22.7	44.8	29.6 ± 1.00	25.69	34.32

The results of the analysis of raw milk samples in Algeria showed that physicochemical parameters and microbiological content were in accordance of the recommended standard values. However clotting properties indicated that raw milk is suitable for cheese making, while milk quality in terms of protein and fat contents remain insufficient to reach the requirement of dairy processors to produce added-value dairy products (Allouche *et al*., 2021).

In Northern Greece, physicochemical parameters analyzed in cow milk are close to those recorded in the national laboratories (Table 2). In fact, milk physicochemical parameters obtained in Northern Greece and Egypt are in accordance within the international recommended values (Muehlhoff *et al*., 2013).

The analyzed sheep and goat milk samples were of good quality and safety in Northwest Greece. The future of the Greek sheep and goat dairy chain is promising despite high competition within and outside of the European Union (Pappa *et al*., 2021).

The quality of the raw milk depends on many factors such as the health of the animal, the feed consumed, the milking conditions, the cleanliness of milk equipment, the temperature control from bulk tank through silo storage tank at the processing plant, the cleanliness of tanker and lines and finally the good handling practices at all points in the process are necessary. Detailed information can be found in FAO and IDF (2011) and FACE Network (2016).

Moreover, dairy producers have to deal with control measures imposed by the dairy processors, otherwise their milk is rejected.

Table 3 shows that in Egypt, buffalo milk is more nutritious than cow milk collected from shops as it contains higher fat, protein, lactose and solid in non-fat substance contents which are in agreement with those found by Hamad and Baiomy (2010). The availability of this kind of milk of high quality in the region probably made Egypt the leading producer of milk, cheese, and butter in the MedAgri region (MedAgri, 2020).

It is highlighted that protein and fat contents of cow milk samples collected in Algeria, Greece and Egypt were lower than those found in Poland and Germany (Kuczaj, 2001; CLAL, 2020), which constraint the dairy processors to produce a wide range of dairy products in these countries. In fact, the quality and amount of cheese obtained, not only per volume of milk but also per gram of protein in cheese milk, is important for the economic outcome of the dairy industry (Wedholm *et al*., 2006). Nevertheless, this lack of high quality milk leaded many developed countries to import considerable volumes of cheese and butter from developed countries (around 42% and 11% of world imports in 2015-17, respectively; and these percentages will remain at similar levels in 2027 (OECD and FAO, 2018).

In Algeria, several varieties of camembert are produced with a good taste in recent years. In contrast, few varieties of butters and other types of cheese are produced by the dairy processors. Algeria is still not able to build economically viable dairy transformation businesses as there is not sufficient local dairy production in terms of quantity and quality. Moreover, several of the traditional cheeses as Klila, Bouhezza, takammerite, igounanesare endangered, for various reasons including the unavailability of fodder, the rural exodus and changing dietary habits (Boudalia *et al*., 2020).

In Greece, most of the big companies have a parallel production of milk, yogurt and a variety of cheeses, but there are also many smaller companies producing individual products. These are mainly local cheese producers, producing Protected Designation of Origin (PDO) cheeses. Greece has 22 PDO cheeses, the most known being Feta, Kaseri, Graviera and Metsovone. Milk and cheese represent about 60% of the dairy production (Chasapis and Christodoulaki, 2007-2010). Egypt is one among the main consumers of butter and cheese (OECD and FAO, 2018), but few companies produce full fat cheese from whole milk. Egyptian traditional white cheeses include Talaga, Istanboly and Baramily cheeses. Milk and dairy products are part of a healthy Mediterranean diet which, besides cow's milk, also consists of sheep's, goat's and buffalo's milk-alone or as a mixture- as raw material (2004).

Regarding the milk safety, many chemical contaminants are present in milk and dairy products, as for example pesticides. The implementation of food safety and a regulatory law in dairy and plant farms is required to reduce chemical residues in milk and dairy products (Aytenfsu *et al*., 2016). In many Mediterranean countries, there is a lack of analysis of milk contaminants. In Greece, there exist pesticide analysis laboratories under private or public statement that determine many pesticide residues using modern analytical instruments and established methods. In contrast, few laboratories exist in Egypt and Algeria to provide services on demand of clients. For producing a safe milk, the government must control milk pesticide content at least every season.

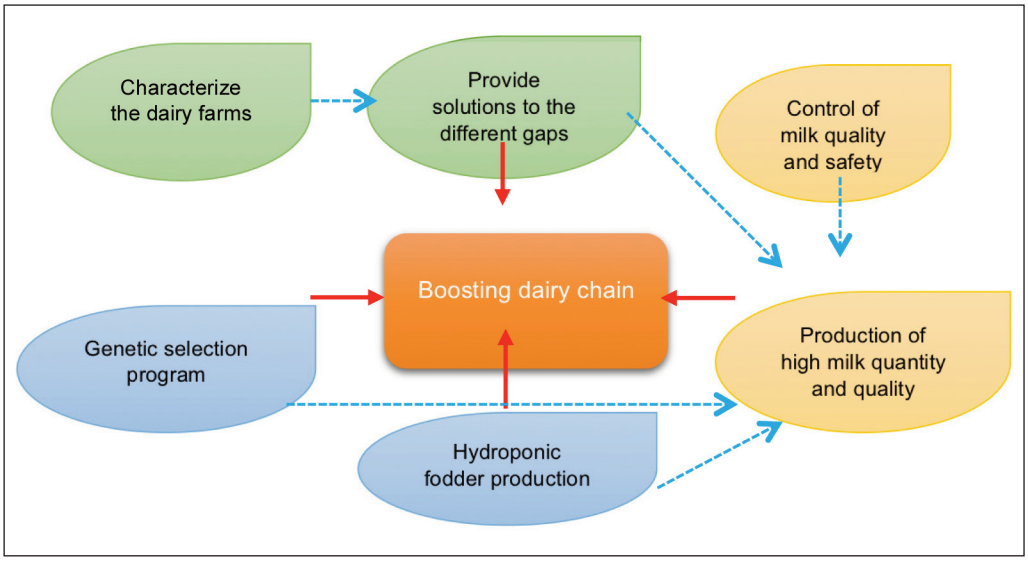
In the frameworks of our research activities, Algerian and Greek teams will collaborate with the Spanish team to analyze pesticides in milk samples using high technology to screen around 150 pesticides in milk samples. These analyses will inform the presence or not of pesticide related public health risks in these countries. It is important that Mediterranean countries collaborate together to assess these contaminants and promote health of Mediterranean populations.

3. Importance of new technologies to improve dairy production

In South Mediterranean region, and more specifically in Algeria and in Egypt, there are not consistent genetic programs to improve dairy cattle breeds, so it is important to start a program to improve cow genetics and select the best heifers who produce high milk quantity and quality, and being at the same time well adapted to the region climate. Algeria has not stopped importing heifers since its independence without satisfying the national milk requirements. Introducing a Marker-assisted technology in Algeria is one of the keys that could help developing dairy sector and would be later disseminated to other Mediterranean countries; this initiative would allow the breeders to identify the best cattle rearing in the area at young age who can produce high protein and fat milk contents, and start then a genetic program. To our knowledge, no cow genotyping laboratory exists in the Southern Mediterranean region; governments should encourage private companies to invest in the provision of tools and high technologies and facilitate their collaboration with breeders, cooperatives and international consultants as this technology is the fastest way to improve milk quantity and quality. Also, introducing fodder production in the arid and semi-arid regions would be a good opportunity for farmers to produce more feed and overcome drought periods. Many local seeds should be tested as wheat and barley to find the best seeds that produce more fodder quantity. In that sense, hydroponic fodder is a good solution to provide animal feed, particularly for small farmers that have a low availability of land and water mainly in dry season, hence it is crucial to know and disseminate this technique in the arid and semi-arid regions.

4. Strategies linking diagram

The following diagram presents an overview on strategies that would improve milk production, milk quality and safety; thus, boosting dairy processors in the Mediterranean region.



IV – Conclusions

The present paper revealed that most farms in Algeria and Egypt were operating at small scale, while at medium scale in Greece. However, in Northwest Greece sheep and goat farms were small, medium or large. Greek farmers respect well the hygienic practices which is not the case of Algerian farm-

ers; therefore, mastitis is not the most observed disease, whereas this disease is widespread in Algerian and Egyptian farms. Although few women are engaged in the work of the visited farms, these women participate in many farm activities from feeding to milking. In the three countries, dairy farmers produce many traditional dairy products for their families, except for Greek cattle dairy farmers who prefer selling all the milk. Sheep and goat milk quality is good, likewise cow milk physicochemical parameters are within the recommended values in all milk samples collected in Algeria, Greece and Egypt; however, the protein and fat contents cannot satisfy the dairy processors demand of high quality (particularly in terms of fat and protein contents). In Egypt, buffalo milk samples taken from shops were more nutritious than cow milk samples. It is necessary to provide guidelines of good practices for Algerian and Egyptian farmers to limit the mastitis in the farms. Also, governments should encourage private sector to invest in new technologies and initiate new actions for improving milk quantity, quality and safety, as genetic selection and hydroponic fodder production.

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Complementary approaches to understand the collective dimension of breed management

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Abstract. This article deals with three levels of organisation (farm, territory and animal population) in two sheep breed cases of the Mediterranean region: the Corsica and the Karagouniko breeds. It illustrates their articulation, implementing the complementary approaches that were developed in two ARIMNET funded projects, DoMEsTIc (2012-2015) and PeRFORM (2017-2020). The approaches refer to the better understanding of the dynamics and interactions between management and value-adding strategies for local breeds, address farming practices at farm level in connection with the breed management at the collective level. Participatory methodologies were also implemented to understand the involvement of stakeholders (public and private) on the dynamics of the breeds and local livestock farming systems. One of the main issues revealed in the analysis and exchanges, was the challenge to find the balance between the individual and the collective goals. Governance to tackle this challenge refers to various level of knowledge, expertise, capacities and willingness to connect people and objectives. It is a key topic, open to new approaches and methodologies and advancing in participatory research could ensure integration and articulations of several levels of concern.

Keywords. Collective organisation – Participatory approach – Breed management – Corsica ewe – Karagouniko breeds.

Approches complémentaires pour comprendre la dimension collective de la gestion des races

Résumé. *Cet article aborde le cas de deux races ovines locales méditerranéennes, les races Corse et Karagouniko, à différents niveaux d'organisation (la ferme, le territoire, la population animale). Nous illustrons les articulations entre ces niveaux d'organisation, à travers plusieurs approches développées dans le cadre des projets DoMEsTIc (2012-2015) et PeRFORM (2017-2020). Il s'agit d'une part de mieux comprendre les interactions entre gestion des races et valorisation des produits et d'autre part de mettre en perspective les pratiques de gestion génétique des éleveurs au niveau de l'exploitation avec le fonctionnement collectif de cette gestion génétique. Des approches participatives ont aussi été proposées pour contribuer à la compréhension des interactions entre dynamiques des races et des systèmes d'élevage mais aussi l'implication de différents acteurs dans ces dynamiques. Les analyses à différents niveaux et les échanges avec différents acteurs ont souligné les enjeux d'articulation entre objectifs individuels et collectifs. Mettre en relation différents types de connaissances et favoriser les échanges sur ces questions peut contribuer à faire face à ces enjeux. Il y aurait un intérêt à aller plus loin dans les approches participatives développées pour favoriser ces articulations.*

Mots-clés. *Organisation collective – Approche participative – Gestion de race – Brebis corse – Brebis Karagouniko.*

I – Introduction

Mediterranean livestock production systems operate in an environment characterized by a high degree of dynamism and uncertainty. One of the aspects of their sustainability is connected with the diversity of the available animal genetic resources in interaction with their farming systems. Among the available genetic resources, local breeds adapted to specific territories and farming systems, are recognized as an important element for the maintenance of various and specific farming systems (Couix *et al*., 2016; Gandini *et al*. 2010; FAO 2015).

In this context, local breeds that have been adapted over generations to satisfy the needs of farmers in the conditions of their local environment are considered as a biological, technical, but also

an organisational object supporting the resilience and the productivity of livestock activities in the Mediterranean hinterlands. As a technical object the local breed with its characteristics contributes to the resilience of the farming system (Couix *et al*., 2016). Breeding practices at farm level aim to maintain or improve the adaptive capacities of the breeds, enabling them to produce in the local context of the livestock systems. These practices express farmer's individual choices at the farm level, but they also reflect decisions taken in the frame of local networks, linking farmers between them and with other operators (such as exchange of sires between flocks, marketing of goods). Therefore, understanding farmer practices at farm level is important but this is not sufficient (Lauvie *et al*., 2015; Perucho *et al*., 2020), as these practices interact with the actions conducted at the scale of the whole animal population.

Managing local breed brings together various stakeholders and is thus highly related to organisational aspects, through stakeholders' involvement and cooperation. The latter though varies within a country and across countries, as illustrated by the analysis provided by Leroy *et al*. (2017). The analysis was based on the information collected by FAO through the preparation process of the 2nd State of the World Country Report (SoW2) and showed the importance of improved coordination between the different stakeholders. In this context, Labatut *et al.* (2011) refer to the rapid evolution of the environmental, economic and technological context in relation to animal genetic resources (AnGR) over the next few years, impacting on the existing relationships among actors and stresses the need to define evolving rules and opportunities of coordination among stakeholders.

As a matter of fact, the local breed as organisational object enables the empowerment of stakeholders around a shared production project, linked with the adaptation of the breed to specific farming systems or value chains. Among the groups of farmers involved in breed management and several stakeholders involved in the valorisation of their products or services, it can be difficult to conciliate the different objectives, for instance the aim of conservation of local breeds and the need to improve animal performance to comply with the product requirements. The involvement of stakeholders with diverse objectives is addressed by several researchers (Lauvie et Couix, 2012), who underline the various interactions between breed and product and the degree of changes that breeders can apply in their breeding practices to comply with the product requirements. In this frame, the dynamics at the farm and at the animal population levels can interact with dynamics at a territory level (like value chains dynamics around specific products for instance) (e.g. Lambert-Derkimba, 2007).

The previous examples indicate that three levels of organisation, the farm, the animal population and the territory, are linked with local breed management. How can they be addressed on specific local breeds' situations?

This article illustrates the articulation between these three levels of organisation, using complementary approaches developed in two ARIMNET funded projects, DoMEsTIc[1] (2012-2015) and PeRFORM[2] (2017-2020) (ARIMNET2, 2017). Two local dairy sheep breeds' situations are considered in our case-studies: the Corsica breed in the Corsica Island (France) and the Karagouniko breed in Thessaly (Greece). The approaches developed (i) propose a better understanding of the dynamics and interactions between management and value-adding strategies for local breeds (DoMEsTIc), and (ii) detail farming practices at farm level and put it in perspective with the description of the various dimensions of a breeding program at the collective level (DoMEsTIc and PeRFORM). Implementation and outcomes of participatory approaches based on the previous research outcomes are finally presented.

1. Mediterranean biodiversity as a tool for the sustainable development of the small ruminant sector: from traditional knowledge to innovation, www.arim-domestic.net

2. Breeding and management practices towards resilient and productive sheep and goat systems based on locally adapted breeds, www.arim-perform.net

II – Material and methods

Concerning the study of the practices at farm level (breeding and flock management practices), 40 semi-structured interviews were carried out with farmers involved or not in the breeding program of the Corsica breed. These semi-structured interviews were enriched with personal observations on farmers' practices by visiting selected farms at key periods, like lambing, weaning and culling periods. Interviews were carried out so that discourse of farmers remains as spontaneous as possible, but oriented on topics of interest. The interviews aimed at specifying the link between the use of collective tools and the on-farm breeding practices. Information on the overall functioning of the farming system was used as illustrative data to discuss this link. The thematic sections of the interview guidelines were i) general information and use of agricultural land, ii) use and perception of collective tools for genetic management, iii) milk production, iv) reproduction, v) animal groups management and feeding practices, vi) replacement and culling practices (rate, temporality, conditions), vii) motives for choosing replacements and for culling animals (Perucho *et al*., 2020). These interviews were carried out in the frame of the PeRFORM project.

At the collective level, an analysis grid focused on simple descriptors of the breed management was developed to assess the level of collective organisation and it was implemented in the two breed cases, the Corsica and Karagouniko sheep breeds, chosen as two examples of North Mediterranean sheep breeds. The descriptors included in the analysis refer to: 1) identification and role of stakeholders, 2) the existence of breeders' association and elements on the activities of the association (breeding program, selection tools, participation of farmers in decision making and other common activities) and, 3) other not institutionalised collective dimension activities, and exchanges with other stakeholders (not directly concerned by the breed management). This analysis grid was filled by using data reported in former studies and in the frame of the DoMEsTIc and PeRFORM projects (Carayol-Costa 2011; Perucho, 2018).

At this same collective level, maps of collective organisation characterizing links between breed management stakeholders and products valorisation stakeholders were developed in each local breeds' situation, identifying the criteria that can be used to analyse territorial dynamics involving those breeds (DoMEsTIc). The criteria identified concern: 1) the type of collective action related to breed and products at a territorial level, 2) the initiatives and main stakeholders, 3) the organisational level of the stakeholders involved, 4) the number of stakeholders and interactions, and definition of their roles, 5) the degree of formalisation of the link between breed and products, 6) the effective links between management of products and management of breed, and 7) the potential tension between different stakeholders on the territory (Lauvie *et al*. 2016).

We finally implemented participatory approaches through discussions with local stakeholders' groups in Corsica (n=1) and Thessaly (n=1) in the frame of the PeRFORM project. The type of participation aimed at "transmitting information about the results of the project in each case-study and improving this information thanks to feedback consultation). The operational aim was mainly to inform stakeholders, and the research aim was mainly to validate and improve results. The composition and the outcomes of the stakeholders' groups are presented in results.

III – Results and discussion

The Corsican breed is the main dairy sheep breed in the island of Corsica. A breeding scheme has been established and the selection criterion is based on milk yield, whereas other criteria are considered by the breeding Centre for the evaluation of breeding animals: resistance to scrapie, standard and rams' horns, and more recently udder conformation. This program is organised to involve several categories of stakeholders. Rams born from elite dams are systematically collected in farms at weaning and raised at the breeding centre of the breeding organisation. At the end of a selec-

tion process, rams that are not kept for artificial insemination (AI) are sold to breeders and others farmers through two annual fairs by the cooperative of the breeding scheme. Following the choice to make the use of AI mandatory for breeders within the breeding scheme, the number of involved breeders has slightly decreased to reach 57 breeders in 2016[3]. Except from the reluctance to AI, other factors limit the accession of farmers to the breeding scheme at the time of the study: farmers outside the breeding program perceive unsatisfactory udder morphology in the selection flocks, remaining of Sarda crossbreeding, mistrust collective action and/or are reluctant to fodder intensification. Despite these perceived limits, the scheme has participated to a global dynamic to maintain the local breed which is used for milk production in the whole island. The case of dairy sheep farming in Corsica illustrated that it is possible to use standardised selection tools (milk recording, genetic evaluation) and tools to disseminate genetic progress in a diversity of farms (AI, selling of rams by the cooperative of the breeding scheme), provided that the adverse effects of collective action are offset, on-farm, by the use of additional selection criteria suited to the farmers' objectives and the constraints of the production environment (Perucho, *et al*., 2020). Indeed, the results from this case study showed that individual farmers' modalities of replacement and culling were not hindered by farmers' participation in the breeding scheme. Factors influencing farmers' perception and use of collective tools, including the modalities of use of milk recording within or outside of the breeding scheme, were linked to (i) the time devoted to animal observation and the work management (flock size, milking method, waged workforce) and (ii) the feeding resources and the potential of land use to reach the production goal (Perucho, *et al*., 2020).

In Thessaly, the Karagouniko sheep breed is challenged by various pressures, connected with i) the dense network of operators importing or trading exotic breeds and their crosses, ii) the dairies policies favouring mainly high milk production (prices are based on volumes delivered to the dairy plant) and iii) the interruptions of the milk recording scheme due to discontinuities in the funding and changes of governance structures. These factors led to the decrease of the population size of the breed, which used to be the predominant breed in the region and also to the decreasing trends of flocks participating to the Official Milk Recording Scheme (n=43 in 2020). Dedicated meetings for the reviewing and decide on new orientations of the breeding goal are not implemented within the Breeders Association, although some meetings are organized in the frame of the ongoing Milk Recording Scheme, mostly oriented to specific technical topics. Artificial Insemination (AI) is not performed at large scale, besides the efforts made recently at a pilot study level, although in the 80s a specific scheme was implemented aiming to promote AI and diffuse rams produced, with the participation of several actors and promising results (Georgoudis *et al*., 1995). Nowadays, dissemination of rams consist in direct interactions between farmers, is mostly restricted to farmers registered in the breeding scheme and based on reputation and level of confidence, whereas the Breeders Association has a minor role in these interactions. The selling of breeding animals is not, in this context, a noticeable way to add-value to local breed-farming.

Concerning the interaction of genetic management with other collective dynamics, the results from DoMEsTIc reported by Lauvie *et al*. (2016), showed that the question of the social organisation was crucial in all the cases studied. The map of collective organisation that was developed to understand the coordination between local actors has shown that when local breed management and product valorisation are initiated at national level, difficulties for local stakeholders to get involved in these projects can be observed. Moreover, the size of the product processing projects and its dependence on a single large structure can influence the developments, as changes in the organisation, status and/or practices of this structure can have global consequences on the sector (Ligda, 2016).

3. Following the breeding scheme sources quoted by Perucho (2018). The total number of sheep's owners reported in Corsica in 2016 was of 568 (key figures of Corsican agriculture (2017 campaign) published by CTC, DRAAF and agricultural chambers).

The participatory approach implemented in the case of the sheep farmers of Western Thessaly aimed to exchange with a diversity of stakeholders on the field results. These results identified the "constraints" of breeding and farming practices that might challenge the medium and long-term efficiency of the breeding program. Participants were mainly farmers of the Karagouniko sheep breed participating in the program, other sheep farmers outside the breeding program (in total 20 sheep farmers), representatives from the Breeders Association, the Regional Livestock Genetic Resources Centre and local actors participating in development initiatives. A first presentation of results obtained in the frame of the PeRFORM project was validated by farmers and initiated a discussion on the current functioning and future challenges of the breeding scheme of the Karagouniko breed sheep. The discussions, mainly among farmers, made clear the need for more active involvement of farmers in the setting of breeding goals and the orientations of the breeding scheme. Other local stakeholders involved in local initiatives emphasized the importance of interaction among actors, through regular communication channels. A better characterisation of animal performances and potentialities through standardized and reliable criteria was also required to encourage dissemination of breeding animals within and out of the nucleus population. Besides, the meeting also pointed the lack of knowledge and understanding of classic collective tools (milk recording, AI) by breeders and farmers not participating in the breeding scheme. This lack of knowledge encouraged even more the practice of crossbreeding with exotic breeds for farmers not participating in the breeding scheme, considered as a quick and easy way to improve quickly milk productivity, without requiring a precise knowledge about individual performances. Communication to farmers on tools for genetic management, data collection on farm and interpretation of generated indicators appeared crucial. Drawbacks and gaps mentioned in this first exchange were finally the need for a better cooperation between breeders and with other actors of the value chain, in order to add-value to the products from the Karagouniko breed.

The participatory approach implemented in the case of the sheep farmers of Corsica aimed to exchange with them on the field results that identified diversity of breeding practices and in link with farming systems among Corsican breed farmers. The exchanges were among 5 farmers participating or not in the breeding scheme of the Corsican breed, 2 accompanying persons (a farmers' wife and an extension services technician who came with a farmer) and 4 members of the research team. The results obtained were validated and a discussion was engaged on the following topics: i) the meaning of the term pastoralism ii) the type of animal to be selected in the future with respect to the evolution of farming systems in Corsica iii) the on-farm breeding practices to maintain the breed's rusticity. Among the small group, which however cannot be considered as representative of the Corsican sheep farmers' population, the vision of the breed and its orientation was not controversial, as the present farmers globally agreed on a need to find and equilibrium between different dimensions (breeds characteristics to be maintained, rusticity, and production challenge). Despite of this shared objective for the management breed, several participants pointed a current trend towards a two-speed selection of the breed: on one side, a selection focused on milk quantity associated to fodder intensification and supported by farmers delivering milk to dairies, in particular in costal lowlands. On the other side, a selection based on a diversity of criteria including robustness, associated with more moderate expectations towards milk quantity and mainly supported by farmers processing cheese on-farm and located in areas where forage production is highly affected by the variability of weather conditions. In this context, the genetic diffusion through rams sold out of the scheme was also mentioned. However, the present organisation and the possible collective organisation to reach such a challenge of an equilibrium between different dimensions were not discussed in depth.

In Corsica and Thessaly, the exchanges initially designed for feed-back consultation also played a role of identifying problems and topics to stakeholders (in a problem finding approach). In the Thessaly case, the exchanges revealed i) individual breeding practices at farm level, ii) linkages between the different levels of organisation and especially tensions between objectives at both in-

dividual and collective levels. The need for engaging other stakeholders in the discussions on the orientations of the selection objectives was identified. In Corsica the organisation at the collective level was finally little discussed. The organisation of the breed management at the collective level, its interaction with global trends in the concerned territories, and with expectations at individual level could be a topic for further participatory work involving more stakeholders.

IV – Conclusions

The main outcomes of the two projects concern methodologies and frameworks developed to support local breeds and enhance their positive impact on rural economies. The interactions between management strategies of local breeds and value-adding strategies were used to provide the keys for identifying possible tensions and difficulties, along with positive aspects to support favourable dynamics. The means by which the breeding practices are connected at different levels to maintain coherence among livestock farming systems, local resources (including the breed) and product valorisation processes were considered. The Corsican case has shown that the collective tools are offset by the use of additional selection criteria according to the farmers' objectives and the constraints of the production environment. It raised the issue of managing a breed under a common selection goal when this breed is raised in a diversity of farming systems. The case-study of the Karagouniko sheep breed revealed the various challenges faced by a collective organisation for the management of a local breed in a context of high antagonism with imported highly productive breeds. In spite of the decrease of local purebred flocks of Karagouniko breed in Thessaly, a trend is also observed in crossbred flocks in Western Thessaly towards the introduction of Karagouniko breeding males in highly productive crossbred flocks (involving exotic breeds) in order to improve the flock response to some constraints of the biophysical environments (Perucho, 2018). Although this trend is recent, the future challenges associated to climate change in the Mediterranean area suggest that the use of local breeds to respond these challenges could increase in the future.

The research on breeding practices at farm level and the interactions with practices at collective level provided new elements on the role played by local breeds in the resilience of farming systems. One of the main issues revealed in the analysis and exchanges, was the difficulty to find the balance between the individual and the collective goals. The diversification of selection criteria of breeding programs could be a solution to tackle the diverse needs of farmers in various farming environments and promote their involvement in breeding schemes.

Good governance is always a crucial aspect, as it contains various level of knowledge, expertise, collective determination, capacities to connect people and objectives. It is an interesting topic for exchange among scientists, regional stakeholders, administration and farmers, open to new approaches and methodologies. Going further in developing participatory research, developing Local Stakeholders Groups with a further degree of participation (an active participation where all participant can contribute to the framing) would be a way to tackle these challenges and could help design collective solutions integrating individual and collective levels and their interrelations.

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Demographics of indigenous bovine cattle farms in Greece, Tunisia and Algeria

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Abstract. Indigenous cattle in the Mediterranean are an integral part of rural societies and ecosystems, as well as, a major source of animal products and income. The present article presents the results from 318 questionnaires developed in the BOVISOL project, in indigenous cattle farms in Greece, Algeria and Tunisia. Demographic information on the farmers, details on the farms, as well as a general description of the production systems are presented and discussed. Farmers, in all three countries have high average age, low to average education level and most of them have a successor in the farm. The farm infrastructures as well as the production characteristics are close to the traditional profile and interconnected to the local climatic and social conditions. Additionally, through the answers gathered, it is apparent that the farms have low cooperation and involvement in production recording schemes or conservation programs. The common problems and goals identified in the present work gives the possibilities to find mutual solutions for present of future issues and emphasizes the need to encourage cooperation between farmers in national and international level.

Keywords. Indigenous cattle – Mediterranean – Farm characteristic – Farming practices.

Démographie des élevages des bovins locaux en Grèce, Tunisie et Algérie

Résumé. *Les bovins locaux en Méditerranée constituent une partie intégrale des sociétés et des écosystèmes ruraux, ainsi qu'une source non négligeable des produits animaux et des revenus agricoles. Ce travail présente les résultats de 318 questionnaires réalisés dans le cadre du projet BOVISOL sur l'élevage bovin local en Grèce, en Tunisie et en Algérie. Les analyses statistiques se basent sur l'étude des données démographiques des éleveurs, les caractéristiques des exploitations ainsi que la description générale des systèmes de production. Les résultats obtenus montrent que cette activité est familiale et héritée de père en fils. Elle est généralement assurée par des éleveurs d'un faible niveau éducatif et d'une moyenne d'âge élevée. La structure des exploitations ainsi que les caractéristiques des systèmes de production demeurent archaïques et dépendent des conditions climatiques et sociales locales. De plus, les réponses collectées montrent une faible implication des éleveurs aux programmes de contrôle laitier et d'amélioration génétique. Les résultats de ce travail donnent la possibilité de trouver des solutions communes à court et à moyen terme pour les présents et futurs défis, en mettant l'accent sur la coopération entre les éleveurs dans le cadre des programmes agricoles nationaux et Internationaux.*

Mots-clés. *Bovins locaux – Méditerranée – Caractéristiques des exploitations – Pratiques d'élevage.*

I – Introduction

Represented by a worldwide population of about 1.4 billion animals, cattle are a major source of animal products and an integral part of human society (Felius *et al*., 2014). As with other domestic livestock species, their dispersal over different continents led to a large diversity of breeds, with characteristics bound to local conditions, resources, and needs (Felius *et al*., 2015). Their wide variety of characteristics, acquired through the course of time, have important cultural, historical, socio-economic and environmental value and, the once the most popular breeds in their specific regions are threatened by more productive specialized breeds during the last century and especially in the present (FAO, 2015). Nevertheless, in the recent past a growing awareness of the need of minimizing loss of genetic resources (Hiemstra *et al*., 2010). has been achieved and a great deal of work is realized towards the conservation of local breeds (FAO, 2015).

In Greece, the majority of local cattle is represented by four breeds: the "Greek Red" (with a population of about 35,000 females), "Vrahykeratiki" (Shorthorn, with approximately 9,300 females), "Katerinis" (with approximately 700 females) and "Sykias" (approximately 300 females, endangered breed). Four Greek breeds are considered as officially extinct (Tinos, Andros, Chios, Kerkyra), the three previously mentioned as threatened (Vrahykeratiki, Katerinis and Sykias) and one (Kea) as nearly extinct. (Domestic Animal Diversity Information System, 2020) The Greek breeds are farmed exclusively for meat production, mainly in the mountainous grasslands of the country. They are reared most of the time in the fields and they are housed only in winter. Their dietary needs are covered mostly by grazing and complementary feed is provided only in the winter.

In Tunisia, local cattle population with Iberian origin counts 191,920 female Units and are mainly (87%) localized in the North especially in the mountainous area (120,000 heads). In this zone, local cattle breeds contribute from 15 to 26% to the milk and meat production. In fact, two breeds are identified: Atlas Brown and Blonde of Cap Bon. The size of Atlas Brown has been declining over the years while the size of the Blonde of Cap Bon is very small indicating that it is exposed to extinction (Baccouche *et al*., 2014).

Algerian autochthonous bovine populations resemble the Brown Atlas, whose pure breed subjects are still preserved in the mountainous regions. It is subdivided into several subpopulations, namely "Guelmoise", "Cheurfa", "Krouminiène", "Chelifienne", "Sétifienne" and "Djerba", which are clearly phenotypically differentiated. The size of these populations has been estimated by the RGA (MADR, 2001) at nearly 896,287 subjects. These populations are characterized by good rusticity, constitute a very important socio-economic element, and contribute to a large part to the feeding of the rural people. Importation of exotic breeds, led to a profound mutation in the genetic structure of the dairy herd in Algeria, resulting in a drastic fall in the numbers of local cattle (Wilson, 2018).

The aim of this study was the evaluation of the current situation in local cattle farms in three Mediterranean countries (Greece, Tunisia and Algeria), in terms of demographics and production systems, using the method of personal interviews with the farmers.

II – Material and methods

This study was contacted in the framework of the BOVISOL (Breeding and management practices of indigenous bovine breeds: Solutions towards a sustainable future) project. The BOVISOL project (2018-2021) is a cooperation of scientific teams from Greece, Tunisia and Algeria and has been formed around the hypothesis that the local bovine breeds must be preserved since they possess a valuable genetic pool and they are a part of the landscape and the biodiversity of rural areas (Boudalia *et al*., 2020). All protocols were approved by the local Data Protection Board (DPB) or the local ethics committee in Greece, Tunisia and Algeria. The study involved data collection from dif-

ferent farms. The participants were informed of the purpose of the project and they have given their consent for their participation and the use of data collected and generated for scientific publications.

This study presents information collected, through individual questionnaires developed in the BOVISOL project, in indigenous cattle farms in Greece (43 farms), Tunisia (100 farms) and Algeria (175 farms). The questionnaires collected demographic information on the farmers, details on the farms, breeds, animals' performance, production systems and market channels. For the purpose of this paper, demographic information is presented, as well as a general description of the production systems. The data were coded, entered a database, corrected and validated by the research group, before being submitted to statistical analysis using IBM SPSS Statistics package version 25 (IBM SPSS, 2017) was used to produce the statistical figures and tables.

III – Results and discussion

1. The farmers

Table 1 shows the age distribution of the farmers in the three countries according to the questionnaire results. It is apparent that Algeria has the most aged farmers with over 60% over the age of 50. Greece has the least aged farmers with 64.4% under the age of 50, while the Tunisian age distribution is more balanced. The age differences of the farmers are projected at their marital status with 20% of the Greek farmers being single while the same figure in the other two countries is less than 10%. It is also interesting that in Algeria and Tunisia more than 50% of the farmers have 4 children or more, while in Greece almost all the farmers have 3 children or less (97.7%). When asked if there is a successor in the farm Algerian and Tunisian farmers confirmed a successor in over 70% of the cases, compared to about 50% of the Greek farmers, which is in accordance with the previous figures.

Table 1. Age distribution of the farmers in countries (in years)

	<= 30	31-40	41-50	51-60	61-70	71-80	81+
Greece	7.3%	17.1%	39,0%	24.4%	7.3%	4.9%	0.0%
Tunisia	8.0%	14.8%	27,3%	20.5%	23.9%	4.5%	1.1%
Algeria	1.7%	15.4%	22,3%	24.6%	23.4%	11.4%	1.1%

The education level of the farmers (Table 2) is higher in Greece where there are no illiterate farmers and more than 50% of them have finished primary or high school, which is in accordance with the younger age of most of the farmers. In Algeria and Tunisia there is a higher percentage of illiterate farmers and a small percentage of farmers that have finished high school. Additionally, in all three countries none of the farmers have any kind of education related to animal production.

Table 2. Education level of farmers

	Illiterate	Primary school	Middle school	High school	Technical	Higher
Greece	0.0%	41.9%	0.0%	37.2%	14.0%	7.0%
Tunisia	62.0%	29.0%	7.0%	0.0%	0.0%	2.0%
Algeria	39.4%	34.9%	19.4%	5.7%	0.0%	0.6%

As shown in Table 3 the farmers in all three countries have significant experience since more than 70% of them work 10 or more years in the field, with the higher percentage represented in Algeria (96.6% with 20 years or more of experience). On the other hand, Greece and Tunisia have both significant populations of relatively new farmers with experience of 10 years or less (Table 3).

Table 3. Experience in animal breeding and occupation type

	Experience in animal breeding				Occupation type	
	<5 Years	5-10 Years	10-20 Years	>20 Years	Full Time	Part Time
Greece	9.1%	15.2%	27.3%	48.5%	100.0%	0.0%
Tunisia	2.3%	26.1%	42.0%	29.5%	84.0%	16.0%
Algeria	0.6%	2.9%	29.7%	66.9%	56.6%	43.4%

In Greece, farming is the sole occupation for all the farmers, while in Algeria and Tunisia significant part of them is occupied in animal production as a part time job. Probably, the acquired income from farming is higher in Greece, allowing the farmers to use it as their sole occupation.

When asked about the reason the farmers chose animal production (Table 4) most of the farmers chose, among others, heritage (Algeria and Tunisia) and attachment to the farming activity (Greece). Both answers reflect on the continuation of the profession from their fathers, as it is also apparent in Table 4 where most of the farmers in all three countries have been taught by their father.

Table 4. Reason of choosing local cattle breeding activity (multiple answers) & source of knowledge

	Reason of choosing local cattle breeding activity (multiple answers)				Source of knowledge on this activity		
	Heritage	Love for farming	Profit	No other activities	Alone	Father	Other farmers
Greece	46.3%	61.0%	39.0%	0.0%	31.0%	64.3%	4.8%
Tunisia	85.0%	0.0%	9.0%	6.0%	12.0%	81.0%	7.0%
Algeria	72.0%	1.1%	30.3%	12.0%	17.1%	81.7%	1.1%

All the preceding characteristics of the farmers are in accordance to previous discussions regarding the sustainability of such pastoral agro-ecosystems (Bernues *et al*., 2011; Ligios *et al*., 2005). The high average age of the farmers surveyed (48 in Greece, 51 in Tunisia, 55 in Algeria) in conjunction with the absence of successors, especially in Greece, and the low education level, are indicators that could lead to the abandonment of such pastoral low-input systems (Lebacq *et al*., 2013).

2. The farms

According to the answers from the surveys (Table 5) the farm buildings in Algeria and Greece are mainly traditional loose housing, and more solid constructions in Tunisia. Regarding the water sources used, in most cases in all three countries, natural sources are used either directly or after storing in tanks (Table 5).

Table 5. Type of farm construction & water source for the farm

	Water source for the farm						Type of farm construction	
	Dam	Local water supply company	River	Spring	Water tanks	Well or drilling	Solid	Traditional
Greece	0.0%	26.2%	11.9%	0.0%	28.6%	33.3%	36.6%	63.4%
Tunisia	0.0%	0.0%	0.0%	3.0%	36.0%	61.0%	64.0%	36.0%
Algeria	1.1%	0.0%	42.9%	25.1%	1.1%	29.7%	35.4%	64.6%

With respect to feed cultivation (data not shown), in Tunisia most of the farmers in the study cultivate feedstuffs, especially hay and straw in order to provide feed to their flocks (pure bovine breeds, sheep and goats and local bovine animals), in contrast to Greece and Algeria, where the respective percentages are significantly lower (48.8% and 31.4% respectively).

On the other hand, as shown in Table 6, the main workforce in the farms is the family members, exclusively in Tunisia, and in high percentages in Greece and Algeria. Specifically, in Greece, 23.3% of the farmers use external workers periodically in the farms, an observation that denotes the more business character of the sector.

Table 6. Number of workers in the farm

	Number of family members working in the farm				Number of external workers in the farm	
	0	1	2	3-7	0	1-3
Greece	27.9%	25.6%	25.6%	20.9%	76.7%	23.3%
Tunisia	33.0%	34.0%	20.0%	13.0%	100.0%	0.0%
Algeria	34.9%	37.7%	16.6%	10.9%	94.3%	5.7%

The surveyed farmers in Tunisia and Algeria conduct no performance recording for their local bovine breeds and also have no participation in a genetic conservation program. On the other hand, 84% of the farmers in Greece have breeds in a genetic conservation program and 68% do performance recording, in the frame of national and/or EU programs.

It is obvious that in all three countries the infrastructures available are far from modern. Additionally, the partial technical consulting, the minimal to absent performance recording and participation in Genetic Resources Programs fail to provide better quality working conditions, improve the welfare and production characteristics and give a comparative advantage to the products (Bernues *et al*., 2011).

3. Production systems characteristics

The production direction is closely connected to the breeds selected in each country (FAO, 2015). All the Greek farms in the questionnaire focused in meat production, and the majority of the farms in Algeria and Tunisia in both milk and meat production (79% and 87% respectively). A small percentage (6.9%) of the Algerian farmers chose breeding as their production direction. The most important reason for choosing the breeds in Algeria and Tunisia was the adaptation of the breeds in the local conditions (Table 7), not apparent in Greek answers indicating the more extreme climatic conditions in the African countries. Performance of the breeds was also important for Algeria and Greece and less selected in Tunisia. The subsidies were selected from few of the farmers in Greece and Tunisia indicating but a small role in their breed choices. Moreover, when questioned about having other breeds in the past few of the farmers in Algeria and Greece responded positively, in contrast with the Tunisian farmers that all of them had another breed in the past that changed seeking for more adapted breeds.

Table 7. Reason(s) of choosing the breed(s). (Multiple answers)

	Adaptation	Heritage	Performance	Technical Support	Subsidies
Greece	20.9%	27.9%	51.2%	0.0%	4.7%
Tunisia	100.0%	7.0%	19.0%	0.0%	2.0%
Algeria	72.6%	61.7%	53.7%	31.4%	0.0%

The production system is characterized by the free grazing of the animals and the periodical housing either in the night or in the winter or both. Specifically, winter housing is more common in Greece than in the African countries, obviously because of the different climatic conditions. In Tunisia, the animals are housed only at night while in Algeria, a large proportion of the animals is never housed (Table 8).

Table 8. Housing period

	Housed in the night	Housed in winter	Housed in the night and winter	Never housed
Greece	23.3%	25.6%	46.5%	4.7%
Tunisia	100.0%	0.0%	0.0%	0.0%
Algeria	38.9%	8.0%	0.0%	53.1%

When questioned about their daily and seasonal activities (Figure 1) the majority of the farmers in Greece and all of the farmers in Algeria and Tunisia performed daily grazing and seasonal feed supplementing, indicating the importance of grazing in all the countries. Milking is an important activity in Algeria and Tunisia, due to their production direction, and performed in only a few cases in Greece, mainly for the household needs. Castrating and dehorning was performed seasonally in Algeria and Greece, and never in Tunisia. It is also important to emphasize that, due to the nature of the production systems, in all three countries cleaning was performed seasonally.

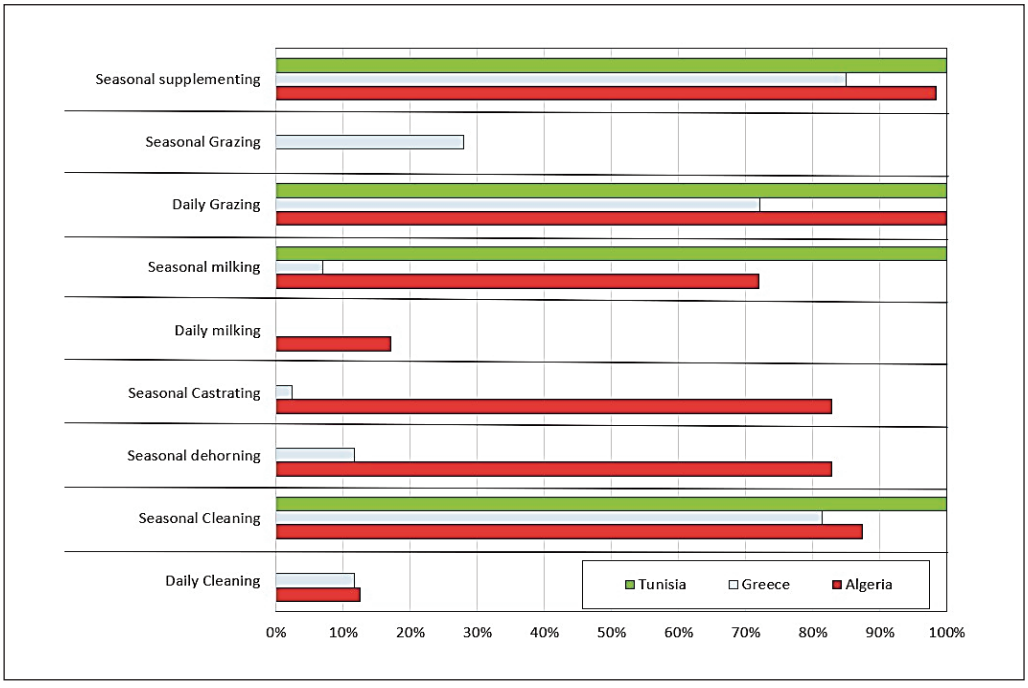

Fig. 1. Daily and seasonal activities of the farmers (% of the farmers).

IV – Conclusions

Besides all the difficulties and imperfections of the indigenous cattle farming systems in all three countries, it is important to emphasize that they are based on the rational use of local resources and allow the production of quality food (Manzano & Salguero, 2018). They are also an important part of rural economy especially in areas with strong environmental constraints, while the local breeds selected by the farmers have developed all the necessary traits to cope with them (FAO, 2015). These systems carry a lot of knowledge, traditions and strong cultural, social and heritage values transmitted through generations. Therefore, it is important to transform these systems while simul-

taneously maintaining all those characteristics that give them their unique traits. They need to evolve in parallel with all the social and economic challenges, the new technologies and the climate change in order for them to have all the necessary tools to cope with any upcoming risks in the future.

The work performed in the BOVISOL project, that this questionnaire is part of, aims to contribute to the sustainability of the local bovine breeds' farming systems by taking into account a) the adaptability of the animals to the local environment, b) the quality of the animal products and c) the economic and cultural value of the systems. The information and experienced share between the countries can be used to provide answers to common problems, as well as prepare the systems for the future (Gandini, *et al*., 2004). This logic of cooperation and common troubleshooting is of utmost importance (Ligda and Zjalic, 2011) especially between the farmers of the same country, same area or same production system, since few of the farmers in the questionnaire were part of a cooperation which indicates the isolation of the farms from common goals and problem solving.

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Analysis of livestock assets, diversity and resilience for family farm systems in three different agro ecological zones in Egypt

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Abstract. The present work analyzes the diversity of livestock assets and management, in relation to human and land assets and its contribution to the household resilience. The analysis conducted on 452family farms surveys in three agro ecological zones of Egypt: the rain fed agro-pastoral zone in the Coastal Zone of Western Desert (CZWD), the hot arid desert oasis in the New valley (NV), and the irrigated hot area of Nile Valley in Upper Egypt (UE). The traditional family farming in Egypt usually include multi-animal species-herd composed of large ruminants (cattle and/or buffalo) and small ruminants (sheep and/or goats), and eventually camels in desert areas, with backyard poultry. The diversity of household faming systems was analyzed according to four dimensions, i.e., human and land asset, livestock diversity and household resilience. The cross analysis based on Multiple Factorial Analysis (MFA) shows very close links between land and crop assets, livestock diversity assets and management under different agro-ecological conditions. There is no exclusive link with either groups, but resilience is positioned as a synthesis of different capacities of households to adapt hazards. The perception of adaptive capacity of local breeds highlights the major external constraints in each location. Overall, increase of monetary and food resilience are linked with livestock activity diversification, even with livestock management embedded in the agro-ecological environment and land asset constraints.

Keywords. Diversity – Resilience – Family farm – MFA – Egypt.

Analyse des actifs de l'élevage, de la diversité et de la résilience des systèmes agricoles familiaux dans trois zones agroécologiques différentes en Égypte

Résumé. *Le présent travail propose d'analyser la diversité des systèmes d'élevage en lien avec les autres actifs du ménage et la résilience des systèmes d'exploitation familiale. Cette analyse est conduite sur la base d'une enquête semi-structurée auprès de 452 ménages répartis dans trois zones agro-écologiques d'Egypte : la zone agropastorale pluviale au Nord-Ouest du désert occidental (CZWD), les zones oasiennes dans la Nouvelle Vallée (NV) et les zones irriguées de la vallée du Nil en Haute-Égypte (UE). La diversité des systèmes d'élevage est abordée à partir de 4 lots de variables : la diversité multi-espèces, la diversité de fonctionnement, la diversité de valorisation des produits, et enfin la diversité de perception. L'analyse factorielle multiple montre des liens étroits entre les actifs fonciers et agricoles et les actifs de diversité et de gestion de l'élevage. Il n'y a pas de lien exclusif entre diversité des systèmes d'élevage ou autres actifs ; la résilience se positionne comme une synthèse des différentes capacités des ménages à s'adapter aux aléas. La perception de la capacité d'adaptation des races locales met en évidence les contraintes environnementales de chaque zone. Dans l'ensemble, l'augmentation de la résilience monétaire et alimentaire est liée à la diversification des activités d'élevage, elle-même conditionnée par les autres actifs du ménage en lien avec les contraintes et atouts de chaque zone agro-écologique.*

Mots-clés. *Diversité – Résilience – Agriculture familiale – MFA – Egypte.*

I – Introduction

Assessment of livestock contribution to vulnerability reduction and improvement of farmers living conditions, is a real challenge in the rural areas of developing countries, in relation to climatic and population pressure on crop and land. Recently there is increasing literature related to livestock contribution to poverty reduction (Freeman *et al.*, 2008; Otte *et al*., 2012) and adaptive capacity to global changes (Alary *et al.*, 2014). Livestock raises also many challenges related to climate change (Rojas-Downing *et al*., 2017 and Thornton and Herrero, 2010). In parallel, resilience as broad range of scientific disciplines became common concept in the last decades (Scheffer *et al*., 2015; Ge *et al*., 2016). Adger (2003) defined resilience as the ability of communities to withstand external shocks, ability to persist and adapt the unforeseen circumstances and risks. The resilience and its relation to adaptive capacity of the whole ecosystem, in the medium and long term, had been described by Walker *et al*. (2006), Folke *et al*. (2002, 2003) and Berkes (2007). They identified four major factors that highly influence the properties of a system to enhance adaptability: (i) the ability to 'learn to live' with changes and uncertainties, (ii) the maintenance of diversity within the system, (iii) the combination of different sources of knowledge, and (iv) the safeguarding of self-organizing capabilities and multi-scale connections.

Interest in resilience and robustness of livestock system to environmental conditions increased substantially in the past decade (Klopcicet *et al*., 2009; Hermesch and Dominik, 2014). In this line, the livestock contribution to the family farm resilience is often searched in its inter-and intra-species composition, population dynamics and management adjustments, allowed by the intrinsic mobility of the herd and local herd rusticity (Nardone, 2000). Colditz and Hine (2016) described livestock resilience as the capacity of the animal to withstand the stress and recover rapidly to its physiological, behavioral, and production status pertained before exposure to stress. Livestock is an essential mean of protection during times of crisis and is crucial for the farm resilience, and contributes in several ways to the family daily subsistence (FAO, 2016).

The traditional family farming system in Egypt usually include multi-animal species-herds composed of large ruminants (cattle and/or buffalo), small ruminants (sheep and goats), and eventually camels in desert areas, with backyard poultry (Aboul-Naga *et al*., 2014). Each animal species produces different final or intermediary products at different time scale (daily for milk and eggs, weekly for chicken, semi-annual or annual for kids from ruminant's species). So livestock produces a diversity of products (dairy products, skin, and manure, wool and draft power). Final products like milk and meat cover family expenses or even agricultural investment over the time. The resilience of the whole system is assessed according to three dimensions: (i) coverage of monetary and food needs at the short term, (ii) transmission of the farm to next generation and (iii) the environmental sustainability in link with pastureland and biomass management at medium and long terms.

The present work analyses the diversity of livestock assets and management, in relation to the other human, land assets, and its contribution to the overall household resilience. The analysis was conducted on a set of 452 household surveys in three agro-ecological zones of Egypt: the rain fed agro-pastoral zone in the Coastal Zone of Western Desert, the hot arid desert oasis (New valley) and the irrigated hot area of the Nile Valley (Upper Egypt).

II – Material and methods

1. Presentation of the studies areas

The objective of the present study is to analyze the diversity in livestock systems, including livestock assets and livestock management and its contribution to family farm resilience, in three different agro-ecological zones of Egypt. Integrated crop- livestock systems are dominant in the studied areas, but

with different components and management. Three agro-ecological zones were involved in the study (Fig. 1): (1) Rain fed area at the Coastal Zone of Western Desert (CZWD), extensive system under hot dry conditions; (2) Desert oasis in the New Valley (NV), semi intensive system under hot dry and intensive solar radiation conditions; and (3) Irrigated Nile Valley of Upper Egypt (UE), with intensive agriculture system under hot conditions.

The number of family farms involved in the study were 207 in CZWD, 135 in the NV and 110 in UE, totaling 452 farms. The surveys were based on a semi-structured questionnaire including six components: (1) family structure and working load; (2) land and cropping system; (3) livestock structure and management; (4) costs and financial issues; (5) adaptation of local breeds to the prevailing environmental conditions; and (6) perception of the farmers for the advantages and disadvantages of sheep and goats local breeds. Local breeds prevailed are mainly Barki sheep and goats in the CZWD, Wahati sheep and goats in the NV and Saidi sheep and goats in UE.

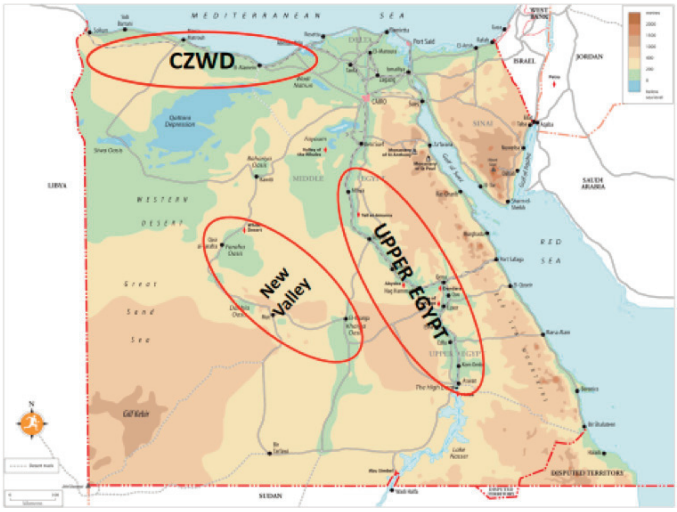

Fig. 1. Map of the studied agro-ecological zones.

2. Analysis of the links between the groups of assets, livestock diversity and the overall diversity

Each group of assets or capacity were addressed by a set of variables (Tables 1 and 2). In total, five main sets have been chosen in link with our main objective to understand the links (causal or correlated) between the human and land asset, the livestock diversify and perception, and the overall resilience of the family farm system.

The livestock diversity is analyzed according to threeperspectives (Table 1). The first one is related to the assets' diversity in link with the flock composition in terms of species and the percentage of reproductive females for each species. The second one is based on livestock management in link with feeding and health management. The third one is related to animal marketing valorization in link with live animals, milk and wool commercialization.The resilience approach is based on three components, i.e. the monetary poverty in relation to the poverty threshold in the country, the transission to next generation in link with land and livestock potential transmission, the food autonomy in relation to milk and meat consumption and, finally, the environmental perspective in link with manure use and the grazing potential.

Table 1. List of quantitative variables

Themes	Variable	New variable label	Mean ± SD
Human assets	Household size	HHsize	8.62 ± 5.52
	Age of the family head	age	45.24 ± 13
	Education level of the family head	edu	2.79 ± 1.33
	Number of women	women	1.64 ± 1.37
	Number of adults	adult	5.36 ± 4.30
	No of family members employed out farm	employ	0.35 ± 0.74
	No of family members working as temporary workers	tempLab	0.27 ± 0.81
Land and crops assets	Total cultivated area_ha	cultiArea	17.43 ± 46.68
	Pastureland area_ha	pasture	15.35 ± 39.64
	Rented land_ha	landRent	0.49 ± 1.34
	Irrigated land_ha	landIrrig	0.53 ± 1.71
	Cultivated land in trees_ha	tree	4.26 ± 12.63
	Cash crops area_ha	cashCrop	0.98 ± 1.16
	Crop income/total income	incCrop	0.418 ±
Livestock diversity	No of animal species	nbspecies	2.78 ± 1.02
	Sheep and goats flock size	sheepGoat	194.52 ± 308
	Large ruminant flock size	cattleBuf	3.8 ± 6.41
	Total TLU*	TLU	38.04 ± 53
	Sheep and goats/ total TLU	sheepGoatTLU	0.74 ± 0.32
	Cattle and buffalo/total TLU	cattleBufTLU	0.26 ± 0.31
	Reproductive females/ sheep flock	RSheep	0.56 ± 0.21
	Reproductive females/ goats flock	RGoat	0.44 ± 0.25
	Reproductive females/ cattle flock	RCattle	0.30 ± 0.34
	Reproductive females Buffalo flock	RBuf	0.05 ± 0.20
	Grazing months	grazing	2.61 ± 2.97
	Maximum distance of grazing	grazDist	8.69 ± 22.27
	Forage crop in winter	forageW	0.28 ± 0.36
	Forage crop in summer	forageS	0.17 ± 0.34
	Dry matter intake from mixture/ total DM intake	DMmixt	0.24 ± 0.31
	Health cost/sheep	healthCost	18.25 ± 31.23
	Self-consumed milk/total milk production (cattle milk)	bovMilkCons	0.19 ± 0.39
	Self-consumed milk/total milk production (goat milk)	goatMilkCons	0.05 ± 0.14
	Wool Sheep sale	sheepWool	0.11 ± 0.31
Resilience	Net income per family member per day	netIncPov	7.69 ± 10.18
	Family cash divided by the poverty threshold	familyCash	90.98 ± 197
	Land transmission (total area divided by children)	landTrans	4.38 ± 13.98
	Livestock capital divided by no. of children	capitalLive	23932 ± 39226
	Milk self-consumption (liter/day/person)	milkCons	0.95 ± 2.19
	Meat self-consumption (kg/person/day)	meatCapita	0.15 ± 0.27
	Wheat consumption (kg/day/person)	wheatCons	0.35 ± 0.91
	Manure (in kg DM/feddan)	manure	11.29 ± 28.31

*TLU:total livestock units.

Table 2. List of qualitative variables

Variable				
Sheep and goat perception			**Sheep (%)**	**Goats (%)**
	Adapted to environmental conditions (desert conditions)		16.9	19.2
	Adapted to climate conditions (drought, hot and cold)		28.5	29.4
	Adapted to walk and grazing		4.2	4.3
	Adapted to feed shortage		9.1	9.7
	Adapted to disease		4.5	4
	Best breed (productivity)		15	15
	Good meat		4.7	4.7
	High demand(good market value)		10.9	7.1
	Cultural value		6.2	6.6
Grazing land quality		**CWZD**	**UE**	**NV**
	Low quality (%)	92.7	4.1	3.2
	Medium quality (%)	0	76.3	23.7
	High quality (%)	0	43.7	56.3

In the first step of the analysis,the quantitative variables were transformed into classes to account for their heterogeneous distributions and deviations from normal distributions. Then, we have conducted a multiple factorial analysis (MFA) (Escofier and Pagès, 1994) to analyze the similarities between different sets of variables (called themes, detailed in Alary *et al*., 2020). This analysis allowed us to have a cross analysis between the three first dimensions, i.e. assets basis, the livestock diversity and the overall family resilience.We presented the projection of the variance of the themes on each factor of the MFA,which helps to evaluate the contribution to the total variance and the similarities between tables (Pagès, 2004). The correlations between the tables were estimated using the multivariate correlation coefficient RV (Robert and Escoufier, 1976) which measures the global correlation between the variables of two tables. Based on the coordinates of the individuals on the first factorial plan, we have conducted a clustering analysis (HCA, Ward method) to identify and characterize the main profiles of resilient farming system in the three studied agroecological zones.

3. Co-inertia analysis to study the links between diversity and household resilience

The co-inertia analysis is a general multivariate method of coupling two tables (Dray, 2003). To study the links between the indicators of diversity related to livestock activity and the indicators of household resilience, we were inspired by approaches used in quantitative ecology to study biodiversity by analyzing the links between environmental variables and indicators of plant or animal populations (Dolédec and Chessel, 1994).The principle of co-inertia is as follows. For two sets of variables, the analysis looks for new synthetic variables (t and u) that maximize both the correlation between the variables and their variance. This quantity is called the covariance (cov) or co-inertia and it is maximized for each pair t and u. All pairs of uncorrelated synthetic variables are computed until the total covariance between the 2 tables is reconstructed.

Each pair of factors t and u called scores synthesize the similarities between the individuals and the correlations between the variables on factorial maps. These proximities are visualized on the factorial co-inertia maps which are interpreted in the same way as for a classical factorial analysis. In complement, a statistical test of randomization based on random permutations of the rows of the two tables (Heo and Gabriel, 1997; Thioulouse and Lobry, 1995) was performed to assess the significance of the correlation structure observed and measured by the RV coefficient. This Monte Carlo test which compares the repeated simulated covariance and the observed covariance

is a prerequisite before investigating potential relationships between the variables in the two tables. In this study, we chose to perform the co-inertia analysis with the original quantitative variables (continuous or ordinal scores). The continuous variables were previously log-transformed in order to reduce the skewness of their distribution and to help linearize the pattern of links between continuous variables. All calculations and graphics were made with the R software (R Core Team, 2020) using the factoMineR (Le *et al*., 2008) and ade4 (Dray *et al*., 2007) R packages.

III – Results

1. Cross-analysis of assets, livestock diversity and household resilience

The cross analysis of the different dimensions based on the MFA shows very close links between the land and crop asset ('Asset land') and the livestock diversity asset and management ('Livestock diversity') in link with the agro-ecological conditions ('Location'). Moreover, the whole resilience of the systems is the combination of the land and livestock assets and secondly the human asset ('Asset HH'). We can see that the perception of adaptive capacity of local breed ('Perception') is not an important structuring factor. This perception should be put in link with household asset, notably the experience of the family head.

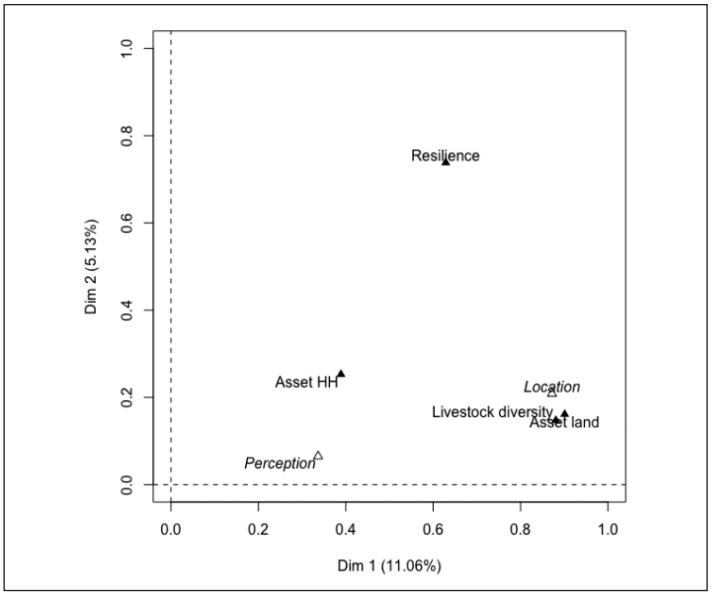

Fig. 2. Representation of the MFA projected variance of the groups of variables in the factorial map (Dim 1 x Dim 2). The active and supplementary variable groups are represented with a filled and an empty triangle respectively.

Overall, we can confirm that the overall resilience of the household farming system is more linked to the livestock diversity (RV=0.41) than the land and crop asset (RV=0.37) or human asset (RV=0.12).

2. Description of the resilience profiles

Based on the MFA, we have developed a clustering analysis that allows to identify 4 profiles of household systems (Fig. 3). Firstly, we can see that the different profiles combining land asset, livestock diversity and resilience are strongly embedded in the three agroecological zones that condition the crop and livestock opportunities. From that, we can identify 2 profiles in the UE (P1) and NV (P2) and 2 profiles in the rain fed zones of CZWD (P3 and P4), which are distinguished according the land and crop system. In one hand, the farming systems in the UE and NV are mainly composed of small plots of land cultivated with wheat and clover in winter and corn and darawa in summer, the two forage crops being used for large ruminants, i.e. cattle and buffaloes. These two profiles differ regarding to the land and livestock assets. In the New Valley (P2), farmers have access to around 10 feddan (or 5 ha) allowing to raise around 10 large ruminants, compared to the average small-scaleland farm system (P1) with around 3 feddan (less than 1.5 ha) in the Nile Valley allowing 5 large ruminants. In the other hand, the farming systems in the CZWD are mainly rain fed systems based on olive and fig trees and cultivated land with barley for sheep and goats. Two FS can be differentiated according to the average flock size (from 300 for P3 to 475 heads for P4), with a higher family food autonomy and diversification in P4.

Overall, we can see an increase of monetary and food resilience in link with livestock activity diversification although livestock management appears mainly embedded in the agro ecological environment and land asset constraints.

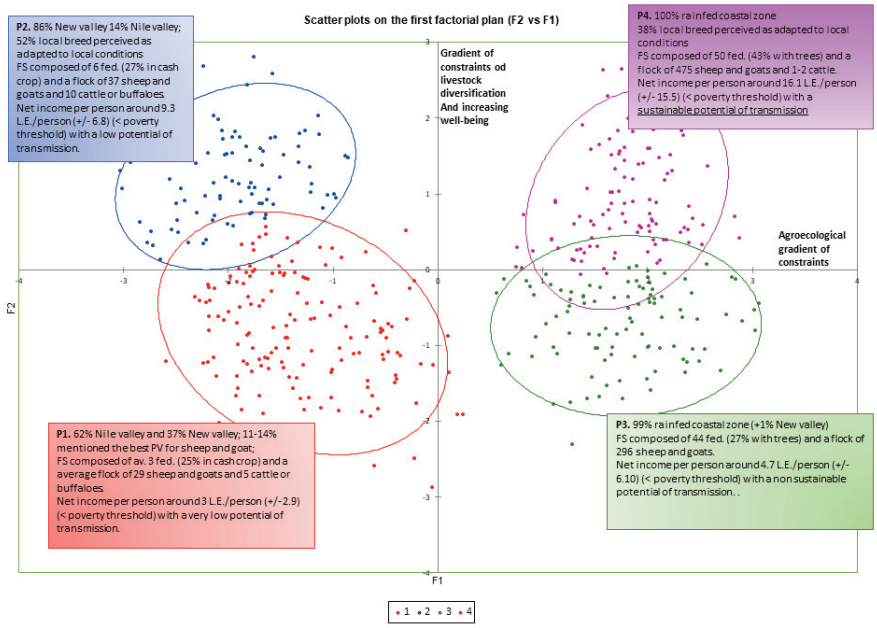

Fig. 3. Identification and description of Resilience profile based on clustering analysis.

In Table 3, percentage of positive answers for different types of adaptive capacity perception (mentioned as first and second importance), was calculated either for sheep and goat. Firstly, we can see similar perception of the adaptive capacity of the animals for the two species, except for the market value, which remains quite similar to sheep in NV and NV, but drops dramatically in the rain fed zone. Secondary, we can see that the desert conditions are more predominant in the rain fed

zone that in the irrigated zones of the Nile and New valley, explaining the relative importance of sheep and goats in the two contexts. We also see clearly that sheep and goat constitute an important asset regarding feed shortage in the less resilient profiles of the two main agroecological contexts in link with irrigation access. Globally more than 10% of the farmers for P1 in irrigated zone and P3 in the rain fed zones mention the capacity of sheep and goat to cope with feed shortage. Finally, the percentage related to the productivity of the breeds and the marketing value reveals clearly the higher role of sheep and goats as source of cash in the irrigated zone compared to rain fed zone where the two species constitute one of the main assets and as savings.

Table 3. Perception of the main adaptive capacities of sheep and goat in each profile

	For sheep (%)					For goats (%)				
Responses to perception of adaptive capacity	P1	P2	P3	P4	Av.	P1	P2	P3	P4	Av.
Adapted to environmental conditions (desert conditions)	10	12	33	28	17	12	12	34	30	19
Adapted to climate conditions (drought, hot and cold T°C)	31	33	21	22	29	33	35	22	22	29
Adapted to walk and grazing	2	0	9	13	4	1	0	6	13	4
Adapted to feed shortage (feed shortage, low feed requirement)	10	6	11	9	9	13	4	13	9	10
Adapted to disease	6	4	3	2	4	6	4	3	2	4
Best breed (productivity)	17	21	7	6	15	18	21	8	7	15
Good/famousmeat	2	3	9	10	5	2	2	8	11	5
High demand, good market value	15	11	1	8	11	9	11	2	3	7
Cultural value	6	10	6	3	6	6	12	5	2	7

3. Links between livestock diversity and resilience indicators

In Fig. 4, the factor maps of co-inertia analysis of livestock diversity and resilience indicators allows to analyze the links between the livestock-induced diversity and the resilience at the household level. The covariance between the 2 sets of data is summarized with 2 factors; the first one representing 75% of the covariance. The Monte Carlo test of the existence of a co-structure showed that it was significant (RV=0.29, p>0.001). On the one hand, variables such as total livestock stock (TLU), the percentage of sheep and goats in the total livestock asset (sheepGoatTLU), as well as indicators of pasture feeding practices (grazing and grazingDist) that concern the CZWD are correlated with the total livestock capital per family member (capitalLive), the potential land transmission per child (land Trans) and the ratio of cash flow compared to the poverty threshold (familyCash) and net income per family member (netIncPov). In the semi-intensive and intensive farming areas, the links between diversity and resilience are described through the production of on-farm forage in winter (forageW) and summer (forageS), the composition of the herd in large ruminants (cattleBuf) and, as a result, percentage of bovine milk consumption (bovMilkCons). These diversity indicators are most closely linked with the wheat consumption per capita (wheatCons), the milk home-consumption (milkCons) and the manure production per feddan (manure).

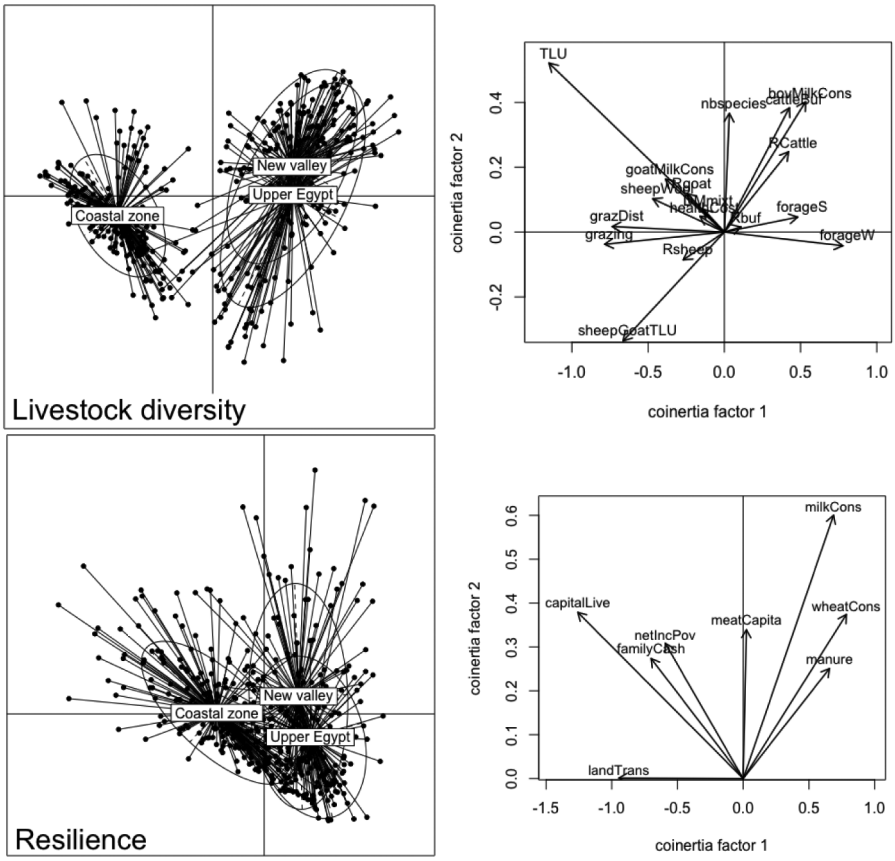

Fig. 4. Factor maps of co-inertia analysis of livestock diversity and resilience indicators. The co-inertia factor 1 (75%) and factor 2 (17%) are reproduced in each graph. Farm scores (left) for each group of variables are represented by agro-ecological zone. The variable scores (right) are represented for each dataset for ease of reading.

IV – Discussion and conclusion

This crossed analysis of livestock diversity in link with land and crop asset, human asset and the overall resilience reveals the significant contribution of livestock diversity to the overall resilience of the family farm systems in the three agro-ecological zones, confirming the crucial contribution of livestock in small-scale family farms, like observed in FAO 2012. Overall, these results confirmed that the livestock diversity is part of the strategy of the farm diversification, especially in land-fragmented and self-sufficiency households farms, as observed in many regions of the Asia and Africa continents. Broadly, approximately 80%of the world's 1.3 billion poor people keep livestock (FAO, 2006, 2009; McDermott *et al.*, 2010; Alary *et al.*, 2011, 2018). In these small-scale farming systems where land property is too small, livestock is often the only opportunity to build up a heritage and an alternative livelihood support. Moreover, animal products accounted for a significant contribution to the daily balanced diet to those who are undernourished or malnourished (FAO 2006).

However, we can deduce different kinds of combinations of strategies behind the livestock diversity in the household resilience according to the farming system and the agro-ecological zone. A

first differentiation is related to the agro- ecological zone that differentiate the livestock system between the Nile and New valley zones and the rain fed zone in the NWCZ (see Fig. 4). As soon as irrigation is possible to allow to cultivate forage crops like berseem and darawa, the majority of farmers attempt to keep a mixed multi-species flock with large ruminants (like cattle or buffalos) and small ruminants (sheep and goats). In these irrigated zones, the majority of milk self-consumption is based on the large ruminant flock. We can see however a differentiation regarding meat consumption and meat marketing valorization between the Nile and New valley. In the Nile Valley, small ruminant constitutes a critical source of cash flow to cover annual expenses, in difference to the farms in the New valley where meat from small ruminant animals contribute significantly to the household consumption (Alary *et al*., 2015). This can also be explained by the sanitary regulation of the live animals' trade between the New valley in the rest of the country. However, this reveals also the specific context of the New Valley in terms of food systems with a higher local valorization of the animal products and co-products in the zone favoring a higher resilience.

In the rain fed zone, we observe positive links between the tree-planted land area and the sheep and goats flock size without significant difference on total cultivated lands in the Wadi or rain fed lands. This means that in the rain fed tree-crop-small ruminant systems that is the dominant system in this zone, there is a sort of trade-off between tree and livestock investments according to the climatic year. Tree plantation allows to invest in the flock after destocking in a drought-period and vice versa the flock secures the income in case of drought that affects directly the olive and fig trees. This strategy is well reflected in the perception where more than 50% of the breeders mentioned the adaptive capacity of the local Barki sheep and goat to their desert and climatic environment, but also in the high link between the percentage of sheep and goats in the total livestock asset with the indicators of resilience in Figure 4. This confirms also the role of net safety of the flock due to the animal adaption to harsh environment (Nardone, 2000; Colditz and Hine, 2016). However, this strategy is completely related to the nature of land access between the wadi and rain fed zone, itself in link with the social position of the family in the traditional society. A limited Wadi area access fragile the overall household resilience (like observed for the profile P3 in our population). This highlights the critical role of the complementarity between crop and livestock activity in the overall resilience of rural household, even in the rain fed zones.

Finally, the perceptions of the various adaptive capacities of sheep and goats confirm the contrasted role of these species in the overall resilience of the family farm system, especially in terms of security in harsh environment (due to desert condition in the NWCZ or hot conditions in the New and Nile Valley, representing in total more than 40% of declarations by farmers), and food and cash diversity in link with small ruminant productivity and marketing value (22 and 26 respectively for goats and sheep). We note that the adaptive capacity of small ruminants to feed short age is mainly mentioned in the irrigated zones and, finally, meaning that this capacity is more crucial when facing economic uncertainty.

In summary, livestock diversification in link with resilience strategy should be examined the interaction between the different combined functions of the livestock species at the farm level. This combination is also dynamic in function of external and internal conditions of the systems. This dynamic role of the livestock diversity can be related with the notion of plasticity and or flexibility of livestock as capital, income generation at different time scale and food self-sufficiency. This calls for rural integrated policies more than agricultural sectorial policies in the 3 agro-ecological zones. Finally, the performance improvement of the animal species in each location should be examined in link with the different dimensions of resistance and the multi-purpose valorization of the animal products and co products.

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Obituary for Andreas P. Mavrogenis

Andreas Mavrogenis passed away on Monday 10th May 2021 at the age of 77 at home in Lefkosia, Cyprus. He was born in the city of Lemesos, Cyprus, in 1944 where he graduated from high school, and then, in 1963, was admitted to the Agricultural University of Prague. It was there that met and married Yiola Petridou. He was awarded the M.Sc. degree in Agriculture in 1968, and the same year, he joined the Cyprus Agricultural Research Institute as a researcher in the field of Animal Production. At the Institute and from different positions, he served livestock research very successfully for 36 years, until retired as Principal Research Officer in 2004. Andreas received his M.Sc. and Ph.D. titles in Animal Science from Raleigh, North Carolina State University, in 1975 and 1977, respectively.

Sheep and goat improvement under the Mediterranean environment, were the main subjects of his research work in animal breeding and genetics. For many years, he was the leader of the Cyprus research programme for selection and crossbreeding in small ruminants, which to a large extent, was concentrated on exploiting the potential of the Chios sheep and the Damascus goat breeds for milk and meat production. His research results were published in many scientific journals and presented at more than 100 conferences all over the world. He was member of Editorial Boards of Journals and peer reviewer, member of Scientific Societies, FAO consultant, and participated in a number of cooperative research projects between Cyprus and Mediterranean countries.

Andreas was highly respected by his colleagues in Cyprus and overseas, for his human and scientific qualities. He devoted much time and effort supporting and helping researchers, especially young ones, to design and statistically analyse their experiments in biological sciences, while at the same time, advising livestock farmers on selection and improvement processes. His overall contribution to improve the efficiency of production of milk and meat from small ruminants under the difficult Mediterranean conditions, is evident, long-lasting and highly appreciated. Apart from organizing and offering specialized training courses in statistics and in genetic improvement of farm animals, he was visiting professor on these subjects at the Cyprus University of Technology.

Besides his dedication and significant contribution to sheep and goat production, Andreas loved soccer. As a teenager, he played for AEL soccer team in the Cyprus premier league, and for a long time thereafter, he served as a member of the Cyprus Soccer Federation. A very pleasant, friendly, low profile, strong and inspiring personality. On behalf of people who knew you, we miss you Andreas.

Andreas is survived by his wife Yiola, his sons Pantinos and Petros, and six grandchildren.

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Addressing the challenges of agro-pastoral farming systems to strengthen their resilience

Edited by:
C. Ligda, G. Hadjipavlou

This issue of Options Méditerranéennes gathers articles from the contributions presented at the online Symposium "Addressing the challenges of agro-pastoral farming systems to strengthen their resilience", organized on 3rd December 2020 by the Mediterranean Working Group and the Livestock Farming Systems Study Commission of the European Federation of Animal Science in the framework of its 71st Annual Meeting. The Symposium focused on the challenges and drivers of change that the livestock sector faces in the Mediterranean and less-favoured areas, and it included two scientific sessions: "Combining the diversity of resources and farming practices to ensure resilience at different scales" and "Diversity of animal genetic resources for resilient farming systems".

The volume also contains articles on the outcomes of selected projects that dealt with the above mentioned challenges from the ARIMNET and ARIMNET2 Calls (supported by the European Union's FP7 Research and Innovation Programme), that aimed to coordinate agricultural research in the Mediterranean.

This publication is contributing towards spreading the scientific knowledge on the role of diversity for enhancing Mediterranean farming resilience, generated from scientific cooperation between researchers from different disciplines and countries of the region.

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