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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 <i>et al.</i> , 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 Caussearde 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 Raïole 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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