Book of Abstracts

of the 3nd Mountain Livestock Farming Systems Meeting of the European Federation of Animal Science

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Summary

The European Federation of Animal Science (EAAP)

The main aims of the EAAP are to promote, by means of active co-operation between its members and other relevant international and national organisations, the advancement of scientific research, sustainable development and production systems; experimentation, application and extension; to improve the technical and economic conditions of the livestock sector; to promote the welfare of farm animals and the conservation of the rural environment; to control and optimise the use of natural resources in general and animal genetic resources in particular; to encourage the involvement of young scientists and technicians. More information on the organisation and its activities can be found at www.eaap.org.

Former Presidents

1949-1961	A.M. Leroy (France)
1961-1967	R. Trehane (United Kingdom)
1967-1972	J.M. Rijssenbeek (The Netherlands)
1972-1978	J.H. Weniger (Germany)
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- Andrea Rosati

European Federation of Animal Science has close established links with the sister organizations American Dairy Science Association, American Society of Animal Science, Canadian Society of Animal Science and Asociación Latinoamericana de Producción Animal.

Welcome to MLF 2024 in Clermont-Ferrand

On behalf of the French Organising Committee, we are very delighted to invite you to attend the Mountain Livestock Farming Systems Meeting co-organised by the European Federation of Animal Science (EAAP), VetAgro Sup and INRAE to be held in Clermont Ferrand, the capital of the Auvergne, from June 5th to 7th, 2024.

The general topic of this Congress will be Adaptation of mountain livestock farming to climate change. Different sessions will be jointly organised to cover various areas of knowledge related to Interaction between farming systems and wildlife, Product quality and mountain farming, and several other topics.

Scientific Committee

- Mauro Coppa - University of Turin
- Giulio Cozzi - University of Padua
- Claire Morgan-Davies - Scotland's Rural College (SRUC)
- Manuel Schneider - Agroscope
- Matthias Gauly - University of Bolzano
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- Caren Pauler - Agroscope
- Paolo Silacci - Agroscope
- Bruno Martin - INRAE
- Fabienne Blanc - VetAgro Sup
- Gilles Brunschwig - VetAgro Sup

Organization Committee

- Gilles Brunschwig - VetAgro Sup
- Mauro Coppa - University of Turin
- Bruno Martin - INRAE
- Fabienne Blanc - VetAgro Sup
- Andrea Rosati - EAAP
- Federico Liguori - EAAP

Local Organizers

With nearly 850 staff spread over 20 Units in 8 locations, the Clermont-Auvergne-Rhône-Alpes Centre of INRAE (The French National Institute for Agriculture, Food and Environment) is widely anchored in the region. Our teams implement research projects characterized by a broad disciplinary representation, as close as possible to the concerns of society. They are involved in numerous international research networks in the fields of plant genetics, animal husbandry and human nutrition.

VetAgro Sup is an institution of higher education and research (ESR) under the aegis of the French Ministry of Agriculture and Food. It is the only establishment in France that trains veterinarians, agricultural engineers, and veterinary public health inspectors. It also runs educational and research programmes centred on the essential theme of global health, addressing issues at the intersection of human, animal, and environmental health.

INTERNATIONAL RESEARCH CENTRE ON SUSTAINABLE AGROECOSYSTEMS
Université Clermont Auvergne

Agro-ecosystems face multiple challenges such as climate change, declining biodiversity, and the shift towards agro-ecological practices. Adapting to this evolving landscape requires addressing economic, societal, and environmental concerns. The International Research Center for Sustainable Agroecosystems aims to enhance the resilience and sustainability of agricultural systems, focusing on cereals and grazing livestock. The International Research Centre – IRC-SAE project on sustainable agro-ecosystems brings together 19 research units INRAE, Université Clermont-Auvergne, CNRS, VetAgro-Sup, involving 259 scientists.

EAAP Working Group on Mountain Livestock Farming

The EAAP Working Group on Mountain Livestock Farming joins forces and competences to identify emerging areas of research and encourage collaboration among researchers from different countries and disciplines. It wants to be a welcoming platform for discussion on livestock production in mountain areas in a broad and transdisciplinary perspective. The experts want to contribute to the dissemination of relevant outcomes by organizing conference sessions within EAAP, meetings and joined events with other related initiatives that will enable researchers and stakeholders to contribute and exchange their new knowledge, experiences and innovations.

VetAgro Sup campus

VetAgro Sup is an institution of higher education and research (ESR) under the aegis of the French Ministry of Agriculture and Food. It runs educational and research programmes centred on the essential theme of global health, addressing issues at the intersection of human, animal, and environmental health.

With 260 years of history and 10 years of multidisciplinarity that is unique in France, VetAgro Sup is the only French institution to train veterinarians, agricultural engineers and veterinary public health inspectors in a global approach to health issues. At the heart of the challenges facing the living world, the school develops its training, research and expertise activities on its two campuses as part of a One Health approach, at the interface of human, animal and environmental health.
VetAgro Sup has strong academic ties. It has officially partnered with the University of Lyon and the University of Clermont Auvergne and Associates, which is classified as I-Site establishments.

VetAgro Sup possesses expertise that it parlays into support for major economic players at the national, European, and international level. It specialises in the domains of food, animal health, the agricultural sciences, and the environmental sciences. The quality of the institution's educational programmes has been recognised by the American Veterinary Medical Association (AVMA), the European Association of Establishments for Veterinary Education (EAEVE), the Commission des Titres d'Ingénieur (CTI), and the World Organisation for Animal Health (OIE).

In 2017, VetAgro Sup joined the Consortium of Universities for Global Health and thus positioned itself as an institution working at the interface between human, animal, and environmental health. The consortium's objective is to employ a multidisciplinary approach to improve the well-being of animals, the Earth, and humans.

At the national level, VetAgro Sup is a member of Agreenium, a body that has brought together 3 research institutes and 14 institutions of higher education in the agricultural sciences.
Educational programmes: VetAgro Sup is training veterinarians, agricultural engineers, and veterinary public health inspectors to confront global health challenges.
Research: Research is the foundation of VetAgro Sup's work. It serves as the basis for the institution's curriculum and promotes the dissemination of knowledge, thus helping to tackle major scientific challenges in public health and the life sciences.
Expertise: With its 17 technical platforms, VetAgro Sup is driving the development of new technologies in the institution's fields of expertise.

The Lempdes agronomy campus, on the periphery of Clermont-Ferrand, is dedicated to training agronomy engineers.
Covering an area of more than 11,000 m², the campus features a collaborative self-catering facility and a student residence.
8 student associations and numerous clubs bring the campus to life, and it also boasts a conservatory orchard and several outdoor patios and gardens.

The Auvergne-Rhône-Alpes region

The Auvergne-Rhône-Alpes region covers an area of 69 711 km2 in the central-east part of the south of France. It is characterised by diverse natural resources and topographies (including high mountains to the east and volcanos to the west), climates, cultures, folklore, architecture, and languages. The region accounts for 11.9% of the French economic output. It hosts 48500 farms (with an average of 59 ha), including 51.9% of them for the production of animal products and 10.4% with both plant and animal production. About 20% and 13% of the farms concern the production of beef and milk respectively, and 11% are with sheep, goats or other herbivores. This places the Auvergne-Rhône-Alpes region 3rd in place amongst the other French regions in agriculture. The region had 13% of organic farms, 30% with other labels or quality signs and 30% with short supply chains.

About Clermont-Ferrand

Clermont-Ferrand, capital of the Auvergne region, is a university town in central France, located at the foot of the Limagne fault and the Puys chain, a natural site listed as a UNESCO World Heritage Site since 2 July 2018. Clermont-Ferrand's Gothic cathedral, built from lava stone, and the Romanesque basilica of Notre-Dame du Port, with its remarkable mosaics, are just a stone's throw from the fountains and statues of the huge Place de Jaude.

France's leading university and research centre, with over 40,000 students – a quarter of the municipal population (150,000 inhabitants) – and 6,000 researchers, it is the first city in France to join UNESCO's learning city network. Clermont-Ferrand has a long industrial tradition and is home to Michelin, one of the world's two largest tyre manufacturers. It is also well positioned in the pharmaceutical, agri-food and aeronautical industries. It is home to three competitiveness clusters.

The Clermont-Ferrand International Short Film Festival is the second largest film festival in France after the Cannes Festival. Clermont-Ferrand is home to a number of famous people, including Vercingetorix, king of the Celtic Arvernes, Pope Urban II, who led the first crusade in 1095, and Blaise Pascal, the French mathematician, physicist, inventor, philosopher, moralist and theologian.

We welcome you and wish you an exceptional stay in Clermont-Ferrand!

Industry Members Club

EAAP started in 2023 a new initiative to create closer connections between European livestock industries and the animal science network. Therefore, the “EAAP Industry Club” was shaped with the specific aim of bringing together the important industries of the livestock sector with our European Federation of Animal Sciences. All companies dealing with animal production (nutrition, genetic, applied technologies, etc.) are invited to join the “EAAP Industry Club” because industries will have opportunity to increase their visibility, to be actively involved in European animal science activities, and to receive news and services necessary to industries. In addition, through the Club, industries will enlarge their scientific network and will receive specific discounts on sponsoring activities.
The Industries that already joined the “EAAP Industry Club” are:

The Club gives:

Visibility • Company name and logo at EAAP website and all relevant documents • Slides with name and logo at Official Events • Priority links with EAAP Socials • Invite, through EAAP dissemination tools and socials, people to events organized by your company • Information disseminated through a brand new Industry Newsletter • Networking • Joining the Study Commissions and Working Groups • Suggest topics to be considered for Annual Meetings Scientific Sessions • Organize Professional Panel through the EAAP platforms • Economic Benefits • One free registration to each Annual Meeting and at every meeting organized by EAAP • Five individual memberships at no cost • Many possible discounts (-30%) to increase company visibility through: EAAP Newsletter, EAAP website, EAAP Annual Meetings and workshops • Support young scientist by sponsoring scholarships named by the company • Co-Organize and sponsor webinars

Make yourself more visible within the livestock industry via the animal science network!

For more information please contact eaap@eaap.org

YoungEAAP

What is the YoungEAAP?

YoungEAAP is a group of young scientists organized under the EAAP umbrella. It aims to create a platform where scientists during their early career get the opportunity to meet and share their experiences, expectations and aspirations. This is done through activities at the Annual EAAP Meetings and social media. The large constituency and diversity of the EAAP member countries, commissions and delegates create a very important platform to stay up-to-date, close the gap between our training and the future employer expectations, while fine-tuning our skills and providing young scientists applied and industry-relevant research ideas.

Committee Members at a glance

- Ines Adriaens (President)
- Jana Obsteter (Vice President)
- Giulia Gislon (Secretary)

YoungEAAP promotes Young and Early Career Scientists to:

- Stay up-to-date (i.e. EAAP activities, social media);
- Close the gap between our training and future employer expectations;
- Fine-tune our skills through EAAP meetings, expand the special young scientists' sessions, and/ or start online webinars/training with industry and academic leaders;
- Meet to network and share our graduate school or early employment experiences;
- Develop research ideas, projects and proposals.

Who can be a Member of YoungEAAP?

All individual members of EAAP can join the YoungEAAP if they meet one of the following criteria: Researchers **under 38 years of age** OR within **10 years after PhD-graduation**.

Just request your membership form (ines.adriaens@kuleuven.be) and become member of this network!!!

EAAP Study commissions

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Scientific programme

Session 1. Adaptation of mountain livestock farming to climate change

Date: Wednesday 5 June 2024; 10:00 - 13:15
Chair: Cozzi / Martin / Blanc

Theatre Session 1

Poster Session 1

Session 2. Interaction between farming systems and wildlife

Date: Wednesday 5 June 2024; 15:00 - 17:00
Chair: Holand / Brunschwig

Theatre Session 2

Poster Session 2

Session 3. Product quality and mountain farming

Date: Wednesday 5 June 2024; 17:00 - 19:35
Chair: Coppa / Silacci

Theatre Session 3

Poster Session 3

Session 4. Local breeds

Date: Thursday 6 June 2024; 8:30 - 10:00
Chair: Pauler / Zanon

Theatre Session 4

Poster Session 4

Session 5. Transhumance in European mountains – challenges and perspective

Date: Thursday 6 June 2024; 10:30 - 12:30
Chair: Holand / Zanon

Theatre Session 5

Session 7. Sustainability and ecosystem services of mountain farming

Date: Friday 7 June 2024; 8:30 - 11:00
Chair: Cozzi / Gauly

Theatre Session 7

Poster Session 7

Session 8. New technologies for mountain livestock

Date: Friday 7 June 2024; 11:00 - 13:30
Chair: Morgan-Davies / Schneider

Theatre Session 8

Poster Session 8

CAP and livestock: challenges and perspectives

W. Burtscher[1]
[1] *European Commission, DG Agriculture and Rural Development, Rue de la Loi 130, 1000 Brussels, Belgium*

In his intervention 'CAP and livestock', Mr Burtscher, Director General for Agriculture and Rural Development in the European Commission, will tackle the challenges and opportunities of European livestock farmers, including mountain livestock farming systems. He will also inform of how the current CAP supports EU farmers in meeting the environmental and climate objectives while maintain their economic sustainability and outline reflections related to possible future developments.

Ecological issues of mountain farming

D. McCracken[1]
[1] *Scotland's Rural College, Hill & Mountain Research Centre, Kirkton Farm, FK20 8RU Crianlarich, United Kingdom*

In spite of their primary function of producing food and fibre, many agricultural landscapes are rich in natural and/or semi-natural vegetation and support species and habitats, often with high conservation value, whose persistence is dependent on the maintenance of specific low-intensity farming systems. Known in Europe as High Nature Value (HNV) farming systems, these are largely – but not exclusively – now confined to mountainous regions and consist of livestock-based systems – such as sheep, goats, cattle and/or horses – grazing rough grassland, moorland, heathland and forest. In addition to maintaining a wide range of biodiversity, HNV systems contribute significantly to the delivery of a wide range of ecosystem services on which society depends. However, the poor socio-economic viability of many HNV systems means that they are currently under pressure from intensification or abandonment, thereby threatening the habitats and species reliant upon them. Recent recovery of large carnivores in Europe and increasing conflicts with HNV systems are also exacerbating their economic decline. This presentation will outline the ecological challenges and opportunities facing HNV farming systems across Europe and emphasise the importance of these systems in addressing both the climate emergency and biodiversity crisis in a future that will involve greater amount of economic and climatic shocks. It will also highlight the rationale behind some of the research and demonstration currently being undertaken and especially what the outputs from these mean for future policy development.

Empirical evidence of trade-offs between strategies for climate change mitigation and adaptation in French mountain dairy cattle farming systems

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Mountain dairy cattle are often considered as agroecology-based systems and supposed to have low impact on GHG emissions. However, they show higher sensitivity to climate stressors. Therefore, the relations between mitigation and adaptation options in this type of livestock system is not that clear. Based on on-farm case-studies, we analyzed the mitigation/adaptation relations in mountain dairy cattle systems. We surveyed 15 dairy farmers in the middle-mountain area of Central France (Cantal) and recorded data on the vulnerability (exposition, sensitivity and options of adaptation) of their farms to climate and socioeconomic hazards and farmers' viewpoints on the relations between some options of mitigation and adaptation to climate change identified from a literature review. We also used data compiled from carbon audits carried out on these farms from 2019 to 2021. A Principal Component Analysis and a Hierarchical Clustering performed on five environmental performance variables from this latter database discriminated four groups of farmers according to two main management strategies. The first one concerned the fodder resource management, with farmers focusing on carbon sequestration (permanent grasslands, hedgerows, agroforestry) and others on the productivity of fodder areas through the use of nitrogen inputs. The second strategy involved the management of both livestock size and cow productivity, which impact GHG gross and net emissions. No links were found between the four groups and their degree of sensitivity to drought. The group of farmers with the highest nitrogen fertilization rate was the most sensitive to rising input prices. According to farmers' viewpoints, there were more antagonisms than synergies between options for climate change mitigation and adaptation, even if some synergies were highlighted. Even if these empirical results need to be validated on a larger sample, they highlight the critical need for further more systemic and locally-situated research to support farmers in developing climate-smart agroecology-based practices.

What strategies should be adopted, for water management, to ensure the sustainability of mountain cheese production in the face of climate change?

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Climate change is significantly affecting mountain livestock production systems, leading for example, to a decrease in grasslands productivity and water management issues. A comprehensive study as part of the Casdar ADAOPT was conducted within the "Tomme de Savoie" sector, aiming to assess water consumption and the potential strategies, initiatives implemented to address it. Focusing on the entire sector, 30 semi-structured interviews were conducted with diverse stakeholders: 18 farmhouse producers, 9 cheese dairies and 3 ripeners. Regarding the impacts of climate change, 40% of the interviewed stakeholders face water access issues; over 50% express concerns for the future. Farmers observe declines in forage yields (50%), while cheese dairies and ripeners are less affected by lower water requirements. However, ripeners highlight an increasing difficulty in maintaining favorable conditions (temperature, humidity) for maturing and preserving cheeses. Implemented strategies vary: farmers mainly implement upstream strategies (56%), such as managing the forage system or reducing herd size, cheese dairies upgrade aging facilities renovating and insulating cellars. Chesse dairies and ripenser may implement more costly solutions but energy consuming. Cost-effective strategies can be used by various stakeholders (water meters, staff awareness, high-pressure spray guns…). Despite the initial assessment, questions persist on water resource management and emerging challenges like energy costs.

A framework to study the resilience of dairy herds to climate change from on-farm data

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Climate change is known to challenge mountain livestock farming systems through its impact on forage resources availability. However, information about their vulnerability to heat waves is meager. Previous studies showed that heat waves can severely affect dairy cows' welfare and activity, their reproductive success and milk yield. Thus, the ability of mountain dairy herds to cope with heat episodes is worth to be addressed. The objective is to develop a framework to examine the resilience of dairy herds to heat waves from milk data gathered on farms. The study was carried out on 1500 dairy herds located in a mountain area (Puy de Dôme, France), covering a period of 22 years. Longitudinal data available for each herd concerned productive (milk yield) and reproductive (calving to calving interval) performances along with cows longevity. Weather data (daily temperatures and humidity) for the same period and area were used to calculate the daily temperature humidity index (THI) at a local scale. Heat stress events (HSE) were identified when THI was both higher than 68 and higher than weekly average for at least three consecutive days. Finally, yearly cumulative sums for both duration and levels of HSE were calculated. Dairy herd resilience was assessed through the ability of a given herd to maintain yearly performances relatively stable when experiencing HSE (being minimally affected or going back rapidly to equilibrium state). Then, resilient and non-resilient dairy herds were contrasted in terms of their characteristics (milk yield, breeds, calvings and lactations distribution). The development of such a framework may be useful to identify levers of resilience at the herd level that would ultimately help dairy farmers better dealing with the expected increase in frequency and intensity of HSE.

Does biodiverse mountain grassland reduce enteric methane emissions?

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Plant secondary metabolites are known to mitigate enteric methane emissions. They can be found in biodiverse pasture, rich in fobs, which have been shown to reduce enteric methane (CH4) production in vitro. We set up an in vivo experiment to measure methane (CH4) emission, dairy performances and digestive parameters of 28 grazing dairy cows, allocated to a low plant diversity level plot (LD, 17 species, H-index = 209) for a 3 weeks pre-experimental period. Then, cows were split for a 6 weeks experiment in two balanced groups: one stayed on LD plot managed under rotational grazing; the other continuously grazed a plot with a high plant diversity level (HD, 58 species, H-index = 323). Milk yield was 32% lower for HD cows while protein content was greater for LD cows (+ 1.5 g/kg). CH4 emission for HD cows was lower (- 14%) compared to LD and CH4 intensity was higher for HD cows (+5.4 g/kg MY). First results regarding volatile fatty acid (VFA) in the rumen showed a higher proportion of acetate in HD cows (73,1% vs 70,4% of total VFA). Phenological stage of LD regressed during the trial because LD cows grazed on regrowth and HD plot passed flowering stage during the last three weeks. More data are needed to understand the underlying physiological phenomenon, but we can hypothesise that a higher level of plant secondary compound could explain the reduction of methane emission of HD cows, despite the increase of herbage fiber content associated to its maturity and the probable lower level of intake. This trial should then bring new insight following in vitro fermentation trial showing a reduction of gas emission for biodiverse mountainous herbage.

Effect of slaughter age on environmental efficiency on beef cattle in marginal area including soil carbon sequestration: a case of study in Italian Alpine area

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A study conducted in the South Tyrolean region examined 20 beef farms, categorized based on the age at which cattle were slaughtered: 10 farms with a slaughter age of 12 months (SA12) and 10 farms with a slaughter age of 24 months (SA24). The assessment utilized a life cycle approach, employing two functional units (FU): 1 kg of live weight (LW) and 1 kg of carcass weight (CW). Key environmental indicators, including global warming potential (GWP100, kg CO2-eq), acidification potential (AP, g SO2-eq), and eutrophication potential (EP, g PO4-eq), were investigated. Additionally, the study incorporated the carbon sequestered by pastures and permanent grassland to estimate the overall carbon footprint. Results revealed that the SA12 system exhibited significantly lower GWP100 values for both functional units, with reductions of 8.5% and 7.4% in terms of LW and CW, respectively, compared to the SA24 system. Specifically, the SA12 system demonstrated an environmental impact in terms of GWP100 at 19.5 ± 1.1 kg CO2-eq/kg LW, which was significantly lower than the SA24 system at 22.9 ± 1.1 kg CO2-eq/kg LW. When factoring in carbon sequestration, the observed values for GWP100 remained significantly lower for SA12 compared to SA24, emphasizing the favourable environmental profile of beef production in the Alpine region of South Tyrol, particularly within extensive parameters and carbon sequestration considerations.

Exploring the role of traditional management practices to cope with climate change in mountain areas

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Livestock grazing systems constitute a traditional activity in mountain areas. They are adapted to vegetation growth cycles in meadows, forests and grasslands, and deliver ecosystem services such as open landscapes, wildfires prevention, biodiversity maintenance and quality products. Climate change poses a new challenge on mountain grazing systems by impacting on its natural resource base. We provide a detailed analysis of the potential impact of climate change on livestock grazing systems in the Spanish Pyrenees using the NODRIZA model to evaluate different scenarios (optimistic, medium, and worst) and adaptation strategies. Under the optimistic scenario, natural pasture quality and productivity enhancement improves cow body condition score, feed self-sufficiency, and gross margin by increasing the length of the grazing season. The medium climate change scenario initially improves farming indicators but returns to current levels in the long term, with adaptation actions resulting in a worsening of farm feed self-sufficiency and gross margin due to the shortened length of the grazing season. The worst climate change scenario severely impacts the functioning of farms from the beginning, and traditional adaptation actions help maintain herds' nutritional state but at lower farm feed self-sufficiency and gross margin. Therefore, alternative adaptation strategies are needed for grazing farming systems in the region to face declining pasture quality and productivity under climate change.

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Plant-based methane inhibitors for cows in mountain grassland regions: land requirements to realize effects

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Mitigating methane emissions from enteric fermentation is a challenge also for grass-based cattle production systems in mountain regions. Since increasing concentrate amounts or using synthetic inhibitors is often no option for various reasons, plant-based feed additives are often mentioned as a chance. We systematically reviewed existing literature including herbs or oil-plants, which grow in European climates. Inclusion condition was the presence of at least three independent in vivo studies for the specific plant. We assessed the average size of effects. Furthermore, we calculated for the example of Switzerland, how much arable land for plantation would be required to achieve the dosages used in the published experiments for the whole Swiss cattle population. For all candidate herbs, the effect was lower than 10% reduction of CH4 per unit of intake. Average effects of higher than 10% were only reached with plant oils (rapeseed, sunflower and linseed) and grape marc. For all interventions fulfilling the minimal number of experiments, land-requirements to achieve the dosages for the total Swiss cattle population reached from 70 to 130% of Swiss agricultural area. The only exemption was Origanum vulgare, which would require only 11% of Swiss arable land, however with an average published CH4 mitigation effect of approximately 3.5%. In conclusion, to date there are only few plant applications suitable for European mountain regions, which are proven in vivo with at least three experiments, and none of them shows a reasonable relation between effort and impact. There is not enough literature for a generalisable assessment of the effects of herbs with mitigation potential if they are included in multispecies pasture swards.

Session 1 Poster 10

What future for Comté PDO systems ? An exploratory study of a multi-actor, multi-stakeholder territory

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Comté, the emblematic cheese of the Jura Massif, has benefited from a PDO since 1958. Thanks to the long-standing collaboration between farmers, cheese dairies and ripeners, the Comté PDO is now the leading French cheese PDO, with production set to reach nearly 72,000 tonnes by 2022. This activity is the economic mainstay of the region, surpassing the timber and tourism industries. However, the area where this cheese is produced, characterized by a mountainous pedoclimatic context and karstic soil, presents social, economic and environmental challenges. The aim of this study is 1) to analyze the current challenges facing the area, and 2) to understand the extent to which PDO farming systems take these challenges into account in their management or in the orientations for the future. Between autumn 2023 and spring 2024, interviews were carried out with local stakeolders and then with those involved in the PDO sector. Five major challenges were identified by local stakeholders: local authenticity, the economy, agriculture, biodiversity and water. The analysis of agricultural production systems in the Comté PDO highlighted three distinct groups of farming systems in terms of production and size, with the identification of a new type of farm (large farms). Cross-analysis of the visions of farmers, sector players and local stakeholders on these issues highlighted a discrepancy between the sector's vision and that of society as a whole. For example, the sector considers that agriculture has a positive impact on the environment (opening up of landscapes, etc.), while other stakeholders see negative aspects (loss of biodiversity, pollution, etc.). This exploratory study has enabled stakeholders to position themselves on agriculture and its effects on the region. The Comté PDO sector will be able to take advantage of these different expectations and forecasts to initiate discussions on the evolution of farming systems.

The coexistence between livestock and large carnivores: costs and benefits

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Coexisting with large carnivores (herein, carnivores) requires a balance between costs and benefits associated with potential negative interactions with human activities, particularly livestock practices. These practices provide important ecosystem services (e.g., nutrient recycling, carbon storage, food production, climate regulation, biodiversity and landscapes preservation). At the same time, the presence of carnivores is essential within the environment. As apex predators, they regulate the abundance of other species through top–down effects on the food chain, thereby enhancing ecosystem stability. Carnivores may thus offer important services to humans by controlling the population of those ungulate species that can adversely impact forests/crops and/or negatively interact with livestock (e.g., competition for trophic resources, spread of diseases). In Europe, the management/conservation of carnivores and livestock practices are regulated by European and National legislations. These regulations vary by Country and typically include compensations for damages and the implementation of prevention measures, and, in some cases, population control through legal hunting. In other Countries such as South America and Central Asia, where livestock practices still represent the mainstay for local communities and/or when compensations may not be available, retaliation stands among one of the main practices used to mitigate livestock predations. Prevention measures and legal hunting can be effective in reducing carnivore–related damages, but their success is context–dependent. Achieving coexistence with carnivores requires a balanced approach and an a–priori evaluation to determine the most suitable measures for preserving both livestock practices and carnivore populations.

Characteristics of wolf predation on cattle in high-value-added breeding territories

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In order to understand and limit the impact of predation on the cattle farming systems, a detailed analysis of all reports of damage to cattle was carried out in Savoie and Haute-Savoie, i.e. 147 reports over the period 2015-2020. In Savoie, the number of damages has multiplied by 7 in 5 years. The seasonality of this predation is particularly marked in April-May and September-October. This predation affects calves (29%) and heifers (29%), as well as adult cows (42%). Of the 63% of victims who died, the majority were calves (43%), but also heifers (31%) and adults (26%). The 37% of injured victims were 7% calves, 25% heifers and 68% adults. The victims were totally consumed in 12% of cases, partially consumed in 30% of cases and the non-consumed victims (58%), found dead or injured, showed lacerations and/or bites up to 21%. These signs of predation were located particularly on the hindquarters (63%), on the neck alone (8%) and on the rest of the body (29%). Victims who were not eaten, lacerated or bitten were characterised by cattle rockfall (21%), lameness or fractures (8%), mastitis (4%), dispersal of the herd or disappearance of calves (4%). This work provides an initial characterisation of wolf predation on cattle. Consumption and the diversity of modus operandi complicate the recognition of predation stigmata and the analysis of damages. This study invites us to question the current public systems and to identify adaptation strategies to deal with this emerging risk, which could have a major impact on grass-fed cattle farming areas, particularly those linked to high added-value production.

CDPNews: Knockledge Transfer und exchange to support coexistence between carnivores and agriculture

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Carnivore Damage Prevention News (CDPNews) is a professional newsletter focused on the complex challenges presented by the coexistence of large carnivores and human activities. It acts as a forum to raise awareness of practical solutions, to facilitate collaboration among researchers, policy makers, agricultural consultants, hunters and farmers and to improve knowledge exchange between countries as well as across the boundaries of traditional disciplines. In addition to numerous articles on conflicts between wolves and sheep, Tigers, pumas and black bears are just as much a topic as waste management, compensation payments and protective fences. Projects and research work as well as interviews and methods are presented from more than 50 countries. This type of knowledge transfer concerns first of all a network of experts. Most of the issues are published in English and don't reach the farmers because of the lack of translation. That's why every country should have their own strategies of implementing this transfer of the knowledge which is generated all around the world. The impact and the outcome of such a magazine is not measurable by the evolution of wildlife damages. The focus of the knockledge transfer stays on communication, education and awareness. These are soft factors which are influencing our strategies of wildlife management and the agricultural practise. CDPNews was first published in 2000–2005. The next series of issues was supported by the European Commission within the LIFE MedWolf Project. The Swiss centre for livestock protection, AGRIDEA, took over coordination in 2018 and published eight issues within the LIFE EuroLargeCarnivores project. Actually the project is funded by WWF Switzerland and WWF Germany. CDPNews will increase the digital communication and the worldwide network with a new website. On the new website www.cdpnews.net, more than 200 articles from more than 300 authors can be downloaded on a searchable database.

Cross-transmission of resistant nematodes between wild ibex and transhumant sheep in French Alps

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In the Alps, domestic sheep are driven into the mountains each summer in areas where wild ungulates such as the Alpine ibex Capra ibex live. In such context, both species could share nematodes, including resistant nematodes. In this study, we aimed to investigate the nemabiome and the frequency of anthelmintic-resistant nematodes in sheep and ibex. Faecal samples were collected from ibex before and after the arrival of sheep in three different areas of the French Alps. After coproculture, DNA was extracted from L3. We performed metabarcoding of the ITS2 rDNA nemabiome using next generation sequencing to identify nematode diversity. We also sequenced isotype 1 of the beta-tubulin gene, in which mutations have been associated with benzimidazole resistance. We found that sheep and ibex have very similar nemabiomes and a relatively high proportion of resistance for some parasite species in both sheep and ibex. Our results suggest that the long-term co-occurrence of sheep and ibex on mountain pastures has promoted the exchange of gastrointestinal nematodes. Despite the absence of sheep on the pasture for more than 9 months, ibex shed eggs of resistant nematodes. Further analysis could investigate the potential role of ibex as a reservoir of resistant nematodes for transhumant sheep and the impact of nematode transmission from sheep on ibex health.

Dandelion density: an index to susceptibility to water vole?

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Changes in farming practices and evolution of landscape mosaic in mid-mountain areas have increased the vulnerability of grasslands to water vole outbreaks. This rodent inhabits a variety of habitat, however it is most prominent in mid-mountain meadows. In many places, cyclical outbreaks occur that lead to substantial fodder loss for farmers. As we have shown in a previous study that dandelions play a primordial role in the diet of water voles, our aim was to estimate the influence of this preference on demography. We focused on the effect of dandelion density on dispersal behaviour, and in particular on habitat selection. We used a drone, to monitor during two years, both dandelion and vole densities on 26 ha in both Massif central and Jura mountains. We then analyzed each picture with an automatic remote sensing algorithm. We found that dandelion-rich plots were more likely to have new colonies. Furthermore, in plots with a low dandelion density, areas denser than the plot average were preferentially colonized. These results show that the strong food preferences influence their habitat selection. That information makes possible to improve the estimate of susceptibility to voles at field plot scale, but also to question farming practices.

Dog predation on flocks of sheep in wolf-free areas: a synthesis based on surveys realised in France

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Within the framework of the joint works carried out with a view to creating an inventory of canine predation sites in several wolf-free areas throughout France, the CERPAM, the pastoralism department of CRA Languedoc Roussillon and VetAgro Sup conducted a study based on surveys carried out in 11 territories attached to 12 French départements. These surveys were conducted between 1999 and 2013 over multi-annual periods chosen before wolves arrived into the territories in order to obtain a database concerning the damage on flocks of sheep attributable to dogs. 307 farming, summer pasture and transhumance units were surveyed, making an average of 24 per territory (minimum 17; maximum 43). The study examines the category of male and female sheep over 4 months old put out to graze. Two indicators were prioritized : the annual frequency of attack and the predation rate. These attacks primarily occur by day and the dogs are seen in 86% of cases. The annual average frequency of dog attacks is 0.22 (minimum 0.10 and maximum 0.47 per territory), representing an average of one attack per farm every 5 years. On average, every dog attack results in the loss of 6.3 animals (from 1.6 to 22.9 per territory). The average predation rate is 0.29%, (from 0.06% to 0.60%), representing 1 animal per year for a flock of 330 animals. Sheep density has no significant effect on the predation rate in sheep farming areas with more than 10 sheep/km². The predation rate would nevertheless appear to increase where sheep density is very low or human density is very high.

Livestock management systems affecting the likelihood of predations by large carnivores in the North–Eastern Italian Alps

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Attacks on livestock threaten grazing practices in mountainous regions, necessitating effective management interventions for human–carnivore conflict mitigation and coexistence enhancement. From June to October 2023, 58 out of 149 stockmen practicing summer grazing on the alpine pasture of the Friuli Venezia Giulia region (North–Eastern Italy) were randomly selected and interviewed. The findings revealed that 43.1% were cattle herders, 15.6% grazed cattle and sheep/goats, and 12.1% only flocks of small ruminants. Pasture management included 53.4% of rotational grazing, 41.4% of free–grazing, and 5.2% of a mix managed (free/rotational) grazing system. All farmers implemented one (6.9%) or several (93.1%) preventive measures against predation events. The presence of sheep and goats significantly increases the likelihood of large carnivore attacks ($\beta = 1.7$, SE = 0.6, $p = 0.004$), as well as the probability of observing a higher number of predated individuals ($\beta = 1.6$, SE = 0.5, $p = 0.005$). The likelihood to observe a lower number of predated animals was significantly higher among those stockmen who adopted the free–grazing system ($\beta = -1.4$, SE = 0.6, $p = 0.02$) and used fixed fences to protect livestock ($\beta = -2.9$, SE = 1.3, $p = 0.04$). Both management practices are more frequently used by cattle herders. Targeted measures are particularly needed for sheep and goats grazing on remote, steep pastures in order to prevent predation events and mitigate raising human–carnivore conflicts.

How to assess animal products qualitiy of mountain livestock farming systems?

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In Europe, the recent decline of ruminant product consumption is accompanied by growing consumer/citizen demand for high-quality products. Expectations are related to both intrinsic quality (product safety, nutritional value and sensory features), and extrinsic quality (animal welfare, environmental footprint, cultural value or farmer income). With their naturalness image and specific intrinsic qualities, mountain products can meet current consumer/citizen demands. Their differentiation is crucial to overcome higher production costs due to limitations in land-use. Research of the past decades highlighted the individual farming practices determining animal products intrinsic quality. Some specific practices encountered in mountain livestock farming (i.e. use of permanent grasslands and local breeds) are among the key drivers of mountain products specificity. Nevertheless, the question of how mountain livestock practices or systems can influence simultaneously the various facets of the intrinsic and extrinsic quality of mountain products is less documented. In this presentation, the emphasis is on recent or ongoing researches that simultaneously take into account intrinsic (safety, nutritional value and sensory characteristics) and extrinsic (animal welfare, environmental footprint, etc.) quality traits. These first studies focused on nutritional quality and environmental impacts assessed by life cycle analyses or multi-criteria approaches. Methodological and conceptual obstacles need to be overcome to take into account other dimensions of the intrinsic (safety, sensory) and extrinsic quality. For the latter, the priority is the inclusion of animal welfare and ecosystem services provided by farms, some of which (i.e. preservation of biodiversity) are essential for characterising mountain farming systems and products.

Exploring the heights: Impact of altitude on dairy milk composition

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The aim of the present study was to assess the impact of altitude on the quality of milk from dairy cows housed in small-scalefarms in alpine area. Therefore, a data set comprising 5,680 bulk milk samples from 32 farms located at different geographical locatedaltitudes was considered. Milk traits such as fat, protein, lactose, free fatty acid, casein, milk urea nitrogen content, pH-value, and somaticcell score were examined in the laboratories of the South Tyrolean Dairy Association using mid-infrared spectroscopy. The data wereanalyzed using a statistical model that considered altitude category, grazing practice, housing system, and season of milk analysis as fixedeffects. The findings revealed a positive association between altitude and milk fat, free fatty acid, and somatic cell count. Conversely,lactose content, milk urea nitrogen, and pH-value in milk from cows kept on farms at higher altitude (>1,200 m a.s.l.) showed a negativerelationship with altitude. Farms located at altitudes above 1,200 m exhibited higher fat, protein, urea, and somatic cell content than farmslocated at lower levels. The results provide new insights into a production effect that has so far received little attention and should beconsidered in farm management (e.g., feeding management, breed decision) to ensure animal health and the associated animal welfare aswell as the productivity of dairy cows reared in traditional small-scale mountain dairy farms.

Functionality of stable isotopes for mountain areas milk traceability

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The stable isotopes $\delta^{2}H$, $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$, $\delta^{34}S$ are widely used in food traceability and authentication studies. For some of them, ^{2}H and ^{18}O, the variability in dairy matrices is a function of latitude, altitude, and distance from the sea, while for ^{13}C the main effect within the productive chain seems to be related to the dietary ingredients administered to the lactating cows (e.g. relative abundance of C4 plants). For nitrogen (^{15}N), the use of organic fertilizer for fodder production and/or pasture determines an increase in its abundance in dairy products too. The abundance of the ^{34}S isotope is a function of the sulfides composition of the soil, the microbial ecology of the soil, plants' aerobic and anaerobic growth. The composition of the cow's ration and the use of locally produced fodder influence the variability of some of the aforementioned isotopes (^{13}C, ^{15}N, ^{34}S). Therefore, the isotopic profile of milk produced by 5 family-owned farms, located at different altitudes and latitudes within a relatively limited geographical area (51 ± 26 km) of mountainous regions of Trentino Alto-Adige and Veneto (Italy), was investigated. The isotopes $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$ and $\delta^{34}S$ highlighted significant differences between the 5 farms while $\delta^{2}H$ showed only trend differences. The $\delta^{18}O$ and $\delta^{2}H$ data was consistent with the well-known abundance gradients of these isotopes in rainfall waters. A multivariate statistical approach based on the investigated stable isotopes allowed to aggregate the five farms into two homogeneous clusters.

Effects of grassland biodiversity on digestive process, milk composition, and microbiota of dairy cows

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The effects of pasture botanical biodiversity on rumen and faecal microbiota composition and milk fatty acids profile was studied in an in vivo and in vitro experiment carried out with 2 groups of 7 dairy cows. Cows were led for 4 weeks on 2 plots with high (HD) and low (LD) levels of plant biodiversity. The herbage from HD was more fibrous and had a higher total tannin content, but lower total fatty acids and C18:3 n-3 contents than LD. Samples of simulated bites, rumen fluid, faeces, and milk were collected at the end of week 4. Though species richness of bacterial and fungal communities were similar, their composition differed and discriminative species have been pointed out for each level of biodiversity. Total gas production and CH4 proportion during in vitro ruminal fermentation of HD herbage was lower than LD, probably because of the partial inhibition of bacterial activity by tannins. Remarkable was the comparable proportion of C18:3 n-3 in milk, despite the lower total fatty acids and C18:3 n-3 content of HD herbage. Plant metabolites could have partially inhibited the activity of ruminal bacteria responsible for lipid biohydrogenation.

A new look at the microbial diversity of indigenous ferments in Beaufort technology and their influence on the organoleptic qualities of cheeses

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The starters used in Beaufort cheese production are derived from traditional microbial cultures. The preparation of these cultures can vary from one dairy plants to another, and can have an impact on their microbial composition. The aim of this trial was to gain a new, more complete picture of the diversity and richness of starters, and to determine whether certain taxon synergies could be linked to organoleptic qualities. To answer those questions, samples of milk, starters and cheeses were taken during 39 production runs in thirteen dairy plants. The samples's microbiota was studied by pasteurian analysis and 16S metabarcoding. This study revealed that 103 bacterial species were present in all the starters, and starters showed only 4 species in common. The starters, which contained an average of 29 bacterial species, could be categorized into six groups, taking into account minority species. Only one ferment group was specific to one dairy plants, while the other groups could be observed in three to five different dairy plants. Links could be established between starters' s group and the organoleptic qualities of the cheeses: the diversity of aromas and the bitterness of the cheeses were not the same according to the groups of starters used. A positive correlation was also detected between the Shannon diversity of the starters and the aromatic diversity of the cheeses.

Effects of production system on fatty acids and proteomics profile of PDO beef from Arouquesa cattle mountain breed

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Mountain systems are crucial for the maintenance of autochthonous cattle breeds and sustainability. Arouquesa breed is produced in mountainous regions in the North of Portugal in a traditional system originating a high-quality PDO beef. This work aimed to describe the effect of production system on meat quality. Arouquesa weaners (n=60) produced in five systems were compared: traditional (TF), animals weaned and slaughtered at 9 months; TF+S1, where a starter concentrate was added (S1); S1+S2, animals fed with S1 until weaning at 5 months and then fed with a growth supplement (S2); TF+S3 and S3 produced like TF+S1 and S1+S2, respectively, but reared with a finishing concentrate (S3) until slaughter at 12 months. The Longissimus thoracis fatty acids profile was quantified through gas chromatography with flame ionization detection and the proteomics profile was assessed through label-free quantification. The TF had a lower final liveweight and average daily gain. The ratio omega-6/omega-3 was lower in the TF and TF+S1 (3.53 and 4.52), whereas the ratio PUFA/SFA was higher in TF+S3 (0.56). We identified 1026 unique proteins some up-regulated (e.g. FSCN1, ALDH1A1) involved in binding, skeletal muscle development and glycolysis influencing meat tenderness and color. In conclusion, the novel systems improved animals' performances whereas the traditional had a nutritionally more favorable beef considering the fatty acids profile. The identified proteins had mechanisms with a group-specific response related to meat quality traits which allows the application of new systems and guarantees the traceability of certified products.

Searching for genotypes adapted to the extensive fattening of beef-on-dairy crosses on pasture

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With the advent of sexed semen, European dairy herds have become an important source of crossbred beef-dairy calves for fattening. As compared to suckler-cow operations, joint milk and meat production has the potential to significantly decrease the carbon footprint of beef. Moreover, for alpine regions possessing extensive grassland resources, such as Switzerland, the use of mountain pastures for human food production is a cornerstone to food security. While semen providers have adapted to the new demand from dairy operations for beef genotypes by identifying "beef-on-dairy" bulls, the resulting crossbred calves are generally fattened in intensive feedlot systems. Fattening of such animals on pastures and mountain grasslands represents a low-input alternative that minimizes the feed-food competition, while maximizing meat output for human consumption. Interest in the extensive fattening of crossbreeds is gaining momentum, as manifested by several European research initiatives and on-farm trials. For instance, one ongoing project compares the beef quality from various husbandry systems along a gradient of intensification. This allows the gustative, nutritive and environmental comparison of intensively fattened crossbreeds in southern Europe to extensively fattened crossbreeds in Switzerland. Another project is testing slaughter results of calves with various beef and dairy genotypes fattened on a gradient of grassland systems, from intensive valley to alpine zone. Despite increased interest, various practical as well as scientific questions remain. For instance, Swiss pasture fatteners still struggle to consistently achieve an acceptable carcass fat class within the limited fattening period. This calls for the identification of beef-on-dairy genotypes that are adapted to the fattening of their crossbred offspring on (low-grade) grassland resources. This contribution aims to introduce pasture fattening of beef-on-dairy crosses as a husbandry system, present ongoing research initiatives, identify challenges of the system and establish the need for a wider European research network on the topic, in order to solve pressing research questions.

Ecosystem services of sheep farming in European mountains

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Sheep are an import part of grazing systems in European mountain areas. They allow the production of human-edible meat or milk on grasslands where no arable farming is possible, and offer multiple additional ecosystem services (ES) such as pastureland conservation or wood fire prevention. However, a systematic overview of ES provided by mountain sheep farming is missing. Moreover, there is little knowledge about public perception of sheep farming and if there are differences among European mountain regions. Considering that the number of sheep is in current decline in many European countries, it is all the more important to present an overview of what society is about to lose. Therefore, we elaborate the multifaceted contributions of mountain sheep farming to the provision of ES by a comprehensive literature review. To analyse the public perception of ES, we conduct a survey among different stakeholder groups, such as local mountain farmers, local non-farmers and non-locals/tourists. For ES as well as their perception, a special emphasis lies on differences among European mountain regions. These differences will be tried to traced back to topographic, climatic, social or political drivers. At the Mountain Livestock Conference we will invite participants to take part in the survey and to distribute it in their local network.

Beef-on-dairy crossbreeds' evaluation for high-quality meat production in Switzerland's mountains

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The objective of this study was to evaluate the meat quality obtained from heifers of three distinct crossbreeds: AN: ♂Angus x ♀Brown Swiss (B); LI: ♂ Limousin x ♀ B; SI: ♂ Simmental x ♀ B, and from one beef crossbreed (♂LI x ♀B) raised in semi-extensive grass-based dietary conditions (n=18 in each group). Within each group, half of the animals (n=9) experienced a continuous growth (CG) receiving grass-silage and hay at barn, while the other half experienced discontinuous growth (DC) induced by including a period of mountain pasture in between barn feeding. Animals were slaughtered at a live weight of 530 kg, and Longissimus thoracis muscle was harvested for meat nutritional, instrumental and sensorial analyses. Multivariate analysis of variance was performed with crossbreed and treatment as fixed effects, and for the sensorial traits, judge and session as random effects. No interaction between crossbreed and treatment were observed. Instrumental tenderness of meat was remarkably high and did not differ between crossbreeds. AN heifers exhibited a higher level of sensorial tenderness compared to the other crossbreeds (6.2 vs. 5.6 on a 0-10 scale, respectively, $P = 0.003$). As compared to CG, DG resulted in a more tender and juicier meat that was less prone to oxidation. Meat from LI heifers and steers had a more favorable polyunsaturated to saturated fatty acids ratio than AN heifers' group, SI heifers being intermediary. In conclusion, this study highlights the high quality of meat from beef-on-dairy cattle fed with semi-extensive grass-based diets typical of mountain areas.

Quality of Parmigiano Reggiano milk, the role of grass in mountain farms

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The research, conducted as part of an Innovation Operational Group in Emilia Romagna (that had obtained funding through the 2014-2020 PSR of the Emilia-Romagna Region), delved into the utilization of green forage to promote sustainable development in the mountainous regions of Parmigiano Reggiano. Over the span of two years (2021/2022), the study assessed the green forage using effects, either provided in the stall or through grazing, as the foundational forage source for dairy cattle in mountainous areas. The aim was to develop strategies for enhancing resilience to the impacts of climate change. The investigation explored the potential impact of substituting different quantities of hay and feed with fresh forage on the quality of milk. The findings from the monitoring activities revealed that the inclusion of green forage in the diet of dairy cattle imparted unique characteristics to the milk. Notably, as the quantity of green forage increased, there was a gradual rise in the milk's content of alpha-linolenic acid and carotenoids. This phenomenon was pronounced in the farm whit pasture, where the percentage of alpha-linolenic acid peaked at 1.60%, compared to the 0.80% observed in farms that use grass in the manger. Furthermore, the parameter indicating milk coloration exhibited higher values in farms that utilize pasture compared to those using grass in the manger. In conclusion, the integration of green forage emerges as a crucial element in expanding the use of self-produced forage in dairy farms. It positively influences the lipid quality of the milk, leading to an increase in alpha-linolenic acid and thus improving nutritional characteristics, which hold potential health benefits for consumers.

Impact of grass-based diet on vitamin B content in cow milk

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Some previous studies suggested that diet can impact the B vitamin content of cow milk. So, milk B vitamin concentrations from cows at pasture could be different from cows fed indoor. Four homogeneous groups of 10 cows, differing according to the proportion of grazed grass in the ration were conducted during the spring-summer period. Two groups had grazed grass as main forage whereas it was corn silage for the 2 other groups. Inside each forage group, a reduction of grass availability, simulating a drought hazard, was performed during the last 2 months. Concentrations of milk vitamins B1, B2, B5, B6 (pyridoxine, pyridoxal, pyridoxamine), B9 and B12 were determined in tank milks collected repeatedly from each group at the end of the experimental period, in September. We observed that the milk was richer in vitamin B2 and B9 but poorer in vitamin B1 and B5 when cows had grazed grass as main forage. Drought decreased milk vitamin B2 but increased B5. Surprisingly, vitamin B12 content was the highest in the milk of cows fed corn silage and having access to pasture for a small time of the day whereas it was the lowest when the access to pasture was fully removed.

Quality of milk produced by animals grazing on mountain pasture in the north of Italy

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In summer, grazing of cows on mountain pastures represents a favourable activity, both for its positive socio-economic impact, and for the attribution of superior nutritional and organoleptic characteristics to dairy products. Some PDO cheeses base their tradition and quality on these aspects, and traceability becomes a fundamental tool to protect and valorise them. In our work, two groups of animals from different breeders were monitored over three years during their summer permanence in an Alpine area in Madesimo (Lombardy, Italy) at an altitude of 1850-2050 m. Cow grazing behavior was monitored using GPS sensors to track animal movements. For the entire summer period, milk samples of each group of animals, used for PDO Bitto cheese production, were collected once a week, analysed for fatty acids and volatiles composition. Data obtained were correlated to the effectively pastured areas, and quality and availability of grass during the season. As expected, milk of animals grazing on mountains showed a high content of omega 3 and CLA, molecules with a positive impact on human health. Moreover, it was evidenced that polyunsaturated fatty acids and terpenes content in milk varied according to the type of pasture (limestone pasture, lush pasture, and Nardus grassland), period of grazing, and weather conditions (temperature and rainfall). Among terpenes, δ-3-carene seems to be a candidate marker to follow the evolution of the quality and phenological stage of pasture flora. This study has shown that monitoring the profiles of volatile compounds and fatty acids in alpine pasture milk not only serves to characterize it, but it can be a very sensitive marker of pasture conditions and of the effects of climate change on the alpine grassland's environment.

Deciphering microbial communities of three Savoyard raw milk cheeses along ripening and regarding the cheese process

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Savoyard cheeses are granted with PDO and PGI which guarantees consumers compliance. The use of raw milk is known to be crucial for specific flavor development. To unravel the factors influencing microbial ecosystems across cheese making steps, according to the seasonality (winter and summer) and the mode of production (farmhouse and dairy factory ones), gene targeting on bacteria and fungus was used to have a full picture of 3 technologies, from the raw milk to the end of the ripening. Our results revealed that Savoyard raw milks are a plenteous source of biodiversity together with the brines used during the process, that may support the development of specific features. Ripening stage was selective for some bacterial species, whereas fungus were mainly ubiquitous in dairy samples. Bacterial structuration is shaped mainly by matrices, differently regarding technologies while the influence of technology is higher for fungi. Production types showed 10 differential bacterial species, farmhouses showed more ripening taxa, while dairy factory products showing more LAB.

What is the effect of switching from a corn-based to a grass-based forage system on the contribution of dairy products to the human nutritional requirements?

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Grass-fed cows compared to corn-fed cows produce milk with a higher nutritional value. However, very few studies have examined the effect of switching from one forage system to another on the contribution of dairy products to meeting human nutritional requirements. The aim of this study was to characterize changes in the coverage of the population reference intakes (PRI) by dairy products at the EU scale, when moving the dairy cows from a corn-based diet to a grass-based diet (from plain or mountainous area). The contribution of dairy products to PRI coverage was calculated on the basis of EU-wide consumption data, the concentration of nutrients in dairy products according to the cows' diet and the European Food Safety Authority and World Health Organization nutritional recommendations. Switching from a corn-based diet to a grass-based diet would have no major impact on the contribution of dairy products to meeting PRI for linoleic acid, calcium, phosphorus and magnesium, or vitamins A, B2 and B12. The change in diet would however lead to a doubling in the coverage of all α-linolenic acid, EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) PRI. However, it would also double the contribution of dairy products to the maximum recommended intake for trans fatty acids, without substantially altering this contribution for saturated fatty acids. This approach will be continued with the integration of water-soluble vitamins and oligo-minerals and be extended to other animal-based products such as beef and poultry, with systems ranging from very intensive to very extensive.

Relationship between milk intrinsic quality and the environmental impact of dairy farms

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This study proposes a simplification of a published multi-criteria evaluation methodology for the production of milk for cheese manufacturing, focusing it on milk quality traits possibly predicted by spectroscopic analyses and CAP'2ER® diagnostics of the environmental impact of the farms. Milk quality scores were constructed by weighing health, nutritional, technological and sensory dimensions of milk quality. Environmental impact scores were constructed by combining CAP'2ER® scores in 5 dimensions: greenhouse gas emissions, eutrophication, soil acidification, space and non-renewable energies consumption and ecosystem biodiversity. The study sample included 15 dairy farms located in the French Massif Central mountains. No correlation has been established between overall milk quality and overall environmental impact scores. High scores for nutritional and biodiversity dimensions and low scores for resource consumption dimension, were associated with farms with a high proportion of grasslands in the usable agricultural area, low stocking rate and low productivity per cow. This demonstrates the importance of defining specific priority objectives, on a farm-by-farm basis, in order to drive changes in agricultural practices. The multi-criteria evaluation model tested here appeared sensitive, but it needs to be tested on a larger scale and in different contexts.

Transfer of dioxins and dioxin-like PCBs in beef meat from Swiss mountainous area: a model-based risk assessment

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Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs) and dioxin-like biphenyls (dlPCBs) are highly toxic contaminants. Bovine meat consumption contributes 15-20% of the PCDD/Fs and dlPCBs human exposure in Western diets, whereas Swiss and German monitoring surveys revealed occasional exceedances of regulatory maximum levels (ML) in suckling husbandry. The aim was to assess the risk of PCDD/F and dlPCB transfer from soil and feed to suckler cows and calves. Eighten databases describing feeding practices, and feed and soil PCDD/F and dlPCB levels were compiled. The two most contrasted feeding systems in suckling husbandry of Switzerland were compared: extreme mountain area (mountain IV) and farms using concentrate feed. Three levels of soil ingestion (1, 3, and 9% of dry matter intake) were considered. According to the distribution of PCDD/F and dlPCB concentrations into feedstuffs and soils, quartiles 1, 2, 3, and decile 9 scenarios were deciphered. Transfer into suckler cow and calf meat (adipose tissues and muscles) were simulated according to those 24 scenarios (2 × 3 × 4) using physiologically-based toxicokinetic models. Slightly higher diet and meat PCDD/F and dlPCB levels were observed in mountain IV compared to concentrate system. Whatever the scenarios, 6 months old calf showed veal meat PCDD/F+dlPCB level 1.4- and 1.6-fold higher than beef meat from 10 months suckling cattle (weaning time) and cow, respectively. In median scenarios, with 9% soil ingestion, 6 months calf reached 4.3±0.3 pg toxic equivalent (TEQ) g^{-1} lipids, higher than the ML (4.0 pg TEQ g^{-1} lipids). It decreased below the ML with 1 and 3% soil ingestion (3.1±0.3 and 3.4±0.3 pg TEQ g^{-1} lipids, respectively). Conversely, for 10-months beef meat, the ML was never exceeded for median scenarios.

Modelling quality traits of Asiago cheese from mountain or lowland feeding systems

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Asiago d'Allevo is a semi-hard quality-labelled cheese characterised by high nutritional and organoleptic quality variability since the milk production is terroir-dependent and mainly affected by the feeding system, especially in the Alps were dairy cows could be kept on grazing permanent meadow. The proximate composition, fat-soluble vitamin A and E and cholesterol content, instrumental colour and tenderness data of 84 cheeses from 3 main feeding systems based on lowland or highland hay (HAY-L or HAY-H) or highland grazing pasture (PASTURE-H) were performed. The dataset was split in a training set (n = 60) to perform a factorial discriminant analysis (FDA) and test set (n = 24) to assess the classification reliability via a confusion matrix and a set of descriptive statistics. The scattergram of the FDA showed a clear separation of PASTURE-H based cheese samples, while a moderate overlapping between HAY-L and HAY-H samples was recorded. The most informative variables were fat-soluble vitamins, lightness (L*), redness (a*) and yellowness (b*). The FDA model highlighted a moderate discriminant capacity for the main nutritional components (crude protein and ether extract), chemical traits (pH and water activity) and instrumental texture. The reliability of the FDA classification model was confirmed by the predictive performance assessed in the test set since a Matthews correlation coefficient (MCC) of 0.84 for PASTURE-H group, and 0.71 for both HAY-L and HAY-H group. Summarizing, the lipidic fractions and colour traits might be a reliable practical application to discriminate alpine pasture-based Asiago cheese, and thus they could be a powerful quality tool to manage specific premium market dairy product along with a higher degree of sustainability.

Feed supplementation to dairy goats' diet in a mountain grazing system: the role of anise (Pimpinella anisum) to improve antioxidant activity in cheese

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Oxidation processes in milk and cheese can result in strong off-flavours and in a loss of nutritional quality.Pasture based dairy products can easily be subject to oxidation due to the high content of PUFA. Aiming to increase cheese antioxidant content, anise supplementation was tested in grazing dairy goats. Twenty multiparous goats homogenous for milk yield (1200 ± 130 g/day), body weight (BW: 45± 4.7 kg) and stage of lactation (60 ±7.6 days) were randomly allocated in two groups (C: control and A: anise) both fed on a natural mountain pasture and with concentrate; group A received in addition 15 g/head/day of dry anise powder (Pimpinella anisum) for two months. Milk yield was daily measured and samples of milk were collected monthly for chemical composition analysis (Milkoscan). Significant differences were observed for milk yield in all sampling period and on overall results (C: 1189,37 and A: 1739,6 g; $P < 0.01$) while lactose, protein and fat content did not change. Cheese samples were collected monthly and analysed for total antioxidant activity (TAC) and total phenolic compound (TPC), disclosing significant differences between groups (TAC: 1,8567 vs 3,2333 mol FeSO4 eq/kg, $P < 0.001$; TPC: 179,983 vs 273,533 mg GAE/kg, $P < 0.001$ for groups Cand A respectively). These results confirm the potential role of anise as galactagogue feed additive in grazing goats and suggest its use to increase cheese antioxidant activity in a pasture-based system. Further results are needed to study the effects on dairy products' flavour and processing properties.

Keynote: The relevance and potential of local breeds

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Local cattle breeds are characterized by their good adaptability to climatic and topographic conditions, as well as to the available fodder resources of a region in which they have been bred and kept for centuries. The structural shift from location-dependent to market-oriented agriculture, evident also in mountain farming, has led to an increasingly intense agricultural production, partially detached from geographical and weather-related constraints. Consequently, local cattle breeds have gradually been replaced by high-performance breeds, as the primary consideration in intensive production systems has been the productivity of a breed rather than its functionality and adaptability to local conditions. Nevertheless, the preservation of indigenous cattle breeds is of extraordinary importance for conserving genetic resources, maintaining small-scale farming systems, and preserving local traditions and cultural heritage. Additionally, local cattle breeds have the potential to differentiate and make regional agricultural products somewhat unique. This allows products to be marketed at higher prices, thereby improving the profitability of a farm. However, this potential is currently only being partially realized. The strategy for marketing agricultural products from local livestock breeds as niche products has been in place for several decades and is regulated at the European level with designations such as Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI). In addition to food production (milk, meat), local cattle breeds provide a variety of ecosystem services by utilizing marginal pastoral grassland areas, thereby preserving alpine agricultural ecosystems with high ecological value and maintaining the cultural landscape that has developed over centuries. Local cattle breeds are part of our tradition and culture. Through their centuries-long breeding in mountainous areas, they allow us to operate a location-bound and resilient agriculture, which follows the reputation of a more sustainable and environmentally friendly agriculture. Therefore, it is our collective responsibility to preserve these special cultural treasures for future generations.

Identity of cows and farmers who milk local breeds in Massif Central

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The Massif Central is home to three local breeds (Aubrac, Ferrandaise and Salers) with deep-rooted historical links to the production of PDO cheeses. These breeds are currently mainly used in suckler systems. The numbers of cows on milk recording are low (161 Aubracs, 83 Ferrandaises and 1156 Salers) and they produced respectively 1985, 2477, 2220 L per lactation in 2021. The main issue with Aubrac cows, whose dairy line has recently been rebuilt, is the high proportion of very short first lactation. Milk yield of Salers cows, who are reared in a traditional system of milking with the calf, has been reclining since 2000 (-10%) mainly because of a reduction in the milking period. In the Ferrandaise breed, the majority of cows registered for milk recording are kept in only 5 farms. Based on 16 socio-anthropological surveys, four distinct ways of thinking and acting were identified within the farmers milking these breeds. The 'optimiser' is a farmer seeking to modernise the local breed in order to adapt the cows to his dairy farming system. The 'caretaker' wants to maintain the tradition by adapting his system to the cows. The 'young technician' is willing to modernise the tradition and finally, the 'former participant' is mainly willing to help maintain the breed. These profiles have a direct influence on the way in which local animals live. In a context of climate change, these local breeds are increasingly attracting the attention of the PDO cheese sector because of the quality of their milk, their longevity and resilience and their importance for the local encroachment of the production.

Using GPS collars to characterize breed variability in cattle grazing behaviour

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Grazing livestock is a major driver of ecosystem services whereas it is present, but it has some limitations depending on the type of systems or the type of management. As Vallentine (2001) described, grazing management has four main principles, being the animal type as one of them. This includes not only species but also the breed which is important specially when the landscape variability is high. Cattle selects its most likely patches of land depending on some physical and biological factors, i.e: slope, distance from water or quality of pasture, but also depending on individual heritable patterns of livestock (Bailey et al., 2015). Traditionally, the animal behaviour had been investigated by direct observation which implicates high costs in terms of money but also time. Since several decades ago, the GPS technology has offered a new paradigm on animal behaviour researching, decreasing dramatically the costs of real-time observation of animals. In this study we analysed the cattle breed variability in grazing behaviour in a high mountain landscape in south-east of Spain. The research zone is located in a communal pastures farm in Sierra Nevada's National Park, the grazing zone has an area of 1400 ha. The minimum altitude of the farm is 1700 masl and the maximum is 2700 masl. For the study, 50 animals were monitored and were from different breeds grouped in heritage breeds (7), commercial breeds (7) and crossbreeds (F1, F2 and F3) (36). The GPS collars used in this study for the collection of the data were set up to collect the data on 30 min intervals. Differences were found in the behaviour of the different breeds in terms of time spent grazing and resting as well as space use.

Daily and seasonal movement patterns of Sarda cows

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Grazing cattle maintain Mediterranean silvopastoral areas. However, knowledge about their daily behavior and impact of seasons is scarce. Thus, we observed 11 Sarda cows, a small local Sardinian breed, by GPS for two years in summer and winter, grazing a 54.3 ha pasture with 50% deciduous woods. For daily analysis, three periods of the day were defined: (1) nighttime, (2) daytime low activity, (3) daytime high activity. We calculated distance to water, speed and space-use evenness (Camargo index CI) for each cow. Cows were farther away from water point at night (816±40 m) than day, especially at low activity (277±40 m), probably an evolutionary strategy to avoid night-hunting predators at water places. Overall, distance to water was small, both in winter (562±56 m) and summer (558±56 m), underlining the importance of the water position to guide cattle's space use. Cows used the space more evenly during high (CI: 0.03±0.002) than low activity (0.01±0.002) and night (0.02±0.002). Seasons did not affect space use evenness (both 0.02±0.002) demonstrating that heat-adapted Sarda cows explore pastures resources even under summer conditions. They walked more in winter (1.19±0.61 km h^{-1}) than in summer (0.32±0.61 km h^{-1}). Although cows moved most during high activity (0.90±0.43 km h^{-1}), they were almost as active at night (0.76±0.43 km h^{-1}) indicating that all-day pasture access is important to allow natural behavior. We conclude that high temperature forces cattle to generally reduce movement and to graze at night. The importance of night and winter grazing will increase under climate change conditions, even for heat-adapted cattle like the Sarda breed

Ecosystem Services provided by Podolian system in marginal areas of Southern Italy: a case study

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Extensive rearing systems of local cattle breeds in the marginal areas of southern Italy are gaining a growing interest among policymakers, researchers, and society for the favorable Ecosystem Services (ESs) they may provide. In order to evaluate the perception of ESs offered by Podolian system in the Basilicata region, 198 respondents, among local actors and stakeholders, expressed their levels of agreement and disagreement (on a scale of 1-5) about the four primary ESs: cultural, regulatory, supportive, and provisioning. The respondents believe that Podolian system play a crucial role in maintaining the natural and rural landscape (over 90% of them agree or strongly agree), controlling the encroachment of shrubs and forests onto pastures and contributing to maintaining biodiversity and soil fertility (80–85%). However, the role of promoting tourism in the region was somewhat controversial, as well as, the results in terms of regulation, as approximately 27% of the respondents still believe that extensive rearing of Podolian cattle results in greenhouse gas emissions that contribute to air pollution, and about 15% agree that it leads to water pollution. For most respondents, Podolian system respects animal welfare (80% agree or strongly agree). In terms product quality, approximately 90% of the respondents either agree or strongly agree that the Podolian system delivers dairy and meat products with high nutritional and sensory properties. However, further researches are necessary to better understand the role of Podolian system in the Basilicata region and provide more explicit guidance for local communities and policymakers.

Population monitoring for milk quality, coagulation parameters and metabolic status as well as economic revenues from milk sales of six local dual-purpose cattle breeds in Italian Alpine Area

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Modern livestock production, driven by demand rather than local constraints also in mountain areas has led to a transition from traditional multipurpose breeds to specialized breeds in resource intensive farming systems. To preserve genetic biodiversity the different national breeding associations for Italian dual-purpose cattle breeds have started the project DUAL BREEDING aiming to describe and valorize the local breeds for promoting their breeding and the maintenance of biodiversity. The aim of the present study was to characterize milk quality and technological properties for quantifying the economic efficiency of various local dual-purpose cattle breeds considering the pricing scenario of the province of South Tyrol as a case. Secondly, milk data was used for analyzing dysmetabolism ketosis/acidosis within breeds. Results reveal the deficiencies of local breeds in terms of milk quality parameters (fat, protein) which are mostly recognized in the milk-payment systems of dairy cooperatives compared to specialized dairy breeds. Therefore, additional payments in form of subsidies should be continued for promoting their continued use in small-scale mountain farms as they provide various non-material functions such as some important ecosystem services being better adapted to the environment (e.g., landscape maintenance, cultural heritage). Furthermore, the phenotypic peculiarity of having a narrow fat-protein ratio for some local breeds biases the assessment of metabolic status through milk data. Therefore, for utilizing Fat-Protein-Ratio (FPR) as an indicator of health status appropriate FPR limits (thresholds) for the studied dual-purpose breeds should be found that may indicate health problems.

Characterization of meat and meat products from the Italian Alpine breed Pecora Ciuta

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In livestock farming, local breeds and traditional farming systems play a crucial role in preserving rural biodiversity, particularly in mountain areas. In recent years, new strategies have been developed to improve the efficiency and conservation of animal genetic resource, through promoting in situ conservation and provisioning ecosystem services. Among them, the valorisation of associated typical food products is essential for the preservation and viability of a breed, addressing both present and future market demands. The aim of this study was to evaluate the quality of meat and meat products from Ciuta sheep, an indigenous sheep breed spread in the Italian Alps, Valtellina and Alto Lario. These sheep are mainly bred for the production of meat and traditional products, however any intervention aimed at enhancing and valorising these productions has been done. Proximate composition and fatty acid profiles were determined in the loin (L. dorsi) and in two typical dry-cured products obtained through the traditional manufacturing of whole or deboned Ciuta sheep legs, violino and bresaola, respectively. Ciuta sheep loins contained 1.5-3.5% fat (40-50% saturated), 20-22% protein, and 1% ashes. Meat from suckling lambs exhibited a fatty acid profile distinguished by a lower saturated fatty acid content if compared to meat from heavy lambs and adult ewes. Violino and bresaola were characterized by 4.5-5.5% fat, 45% protein, and 8-9% ashes, with an energy content of 230-240 kCal/100g. No significant differences were observed between the two products. Our data highlighted the presence of functional fatty acids, such as CLA, OBCFAs, and an optimal n-6/n-3 ratio, making both violino and bresaola from Ciuta sheep valuable meat products for human consumption.

Characterization of the milk of two local breeds of cows: the Bretonne Pie Noir and Froment du Léon

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Despite a clear resurgence of interest, technical references on systems promoting local Breton breeds are almost non-existent. Both breeders and restaurant owners are interested in the specificity of products from local breeds. While their quality is empirically recognized, it has never been precisely described. Farmers are wondering about the intrinsic qualities of dairy products, their organoleptic qualities, and more generally, the notion of overall product quality, to which are obviously associated production practices. The objective of this participatory research project was to improve the understanding of milk qualities of local breeds of dairy cows in their various components. Samples of tank milk associated with surveys were carried out on farms on different breeds of cows (6 in Bretonne Pie Noir and 4 in Froment du Léon). We took samples over 3 periods: April, July and November 2017. We characterized the milks at the biochemical and technological levels. The milk of Bretonne Pie Noir and Froment du Léon was richer in protein and fat than the milk of the main French cows. Protein variants were also quite characteristic of these breeds. This gave them particular technological properties, such as better cheese-making capacity, but also a poorer ability to resist to heat treatments. These milks were also yellower which results from higher concentrations of β-carotene and riboflavin, without this being completely systematic. The particular characteristics of milk from local breed cows associated with grass feeding deserves to be better valued and put forward in short marketing circuits.

Changes in metabolic and inflammation plasma biomarkers during the transition period in Ottonese cows reared on Apennine mountain

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Ottonese is a local (nord-west Apennine) cow breed with uncertain origin. This breed has reared for triple purpose (milk, meat, and work), but it was gradually abandoned because of the poor performances. In 1990s less than 100 animals were counted. Later, a conservation project helped to rise the population to nearly 400 heads. Now it is bred mainly for its rusticity and longevity. We hypothesize different patterns in metabolic and inflammatory responses around calving compared with selected breeds. To verify this, 6 Ottonese cows from a herd on Apennine mountain (Piacenza province) were checked during the transition period, with blood collected at -1, 1 and 2 weeks relative to calving. Cows were fed local hays (grass during dry period, added with alfalfa in lactation). Cows received 1 kg of concentrate the week before calving and 2 kg in lactation. The estimated milk yield was between 8 and 10 L/cow/d. Glucose average values during checked period was 3.6 mmol/L, while concentrations of NEFA (0.45 vs 0.28 mmol/L) and BHB (0.79 vs 0.45 mmol/L) were higher before than after calving. Urea was always markedly low, with average value of 2.8 mmol/L, probably due to the low protein content of the grass hay (7.3% on DM). Also the albumin values were quite low after calving, under 33 g/L. Interestingly, the inflammation after calving was mild (i.e. haptoglobin < 0.3 g/L, and ceruloplasmin <1.7 mmol/L). This condition could depend by an insufficient intake of Cu and trace elements in general, as confirmed by the average low plasma concentration of Zn (<10 mmol/L). Albeit in non-ideal breeding conditions, Ottonese cows are able to manage the stressful period of calving without metabolic disturbances.

Exploring the behavioral genetics of cattle grazing for the sustainable use of the Swiss Alps

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Sustainable pasture use requires suitable grazing livestock. Novel research has revealed a genetic basis of grazing behavior by associating the glutamate metabotropic receptor 5 gene (GRM5) with the movement of Hereford cows grazing steep and rugged grasslands in New Zealand. The study also reported a predominance of GRM5 variants C and B, and much lower frequency of A in this population. In a follow-up exploratory study, we asked if similar GRM5 associations and variant frequencies are observed in different cattle breeds elsewhere. Grazing behaviours were derived for GPS-tracked mature cows (n = 17; 12 Highland and five Original Brown) when free-range grazing in the Swiss Alps. Gene variation was determined using PCR-single-strand conformation polymorphism (PCR-SSCP) analysis. The Swiss cattle had only three of a potential six GRM5 genotypes: AC, BC and CC (3:3:11). Variant C was the most common (frequency 82%) and present in all the cows, while the A and B variants were equally represented (9%). The results suggest differences in grazing behaviour among GRM5 genotypes in Swiss cattle, although the differences did not reflect those observed in the New Zealand cattle. The unbalanced frequency of GRM5 genotypes found in the Swiss cattle herds may bring opportunity for genetic selection to adapt their grazing behaviour to alpine landscapes. A larger sampling is needed to confidently establish the effects of GRM5 variation on grazing behaviours.

A comprehensive view on transhumance in Europe, with challenges and opportunities

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Mobile pastoralism optimised humanity's use of very abundant rangeland resources, yet variable in space and time. In Europe, severely constrained by competing land uses, transhumance developed for centuries as the dominant form of livestock mobility. It maintained a logic of sustainable exploitation of rangelands, preserving biodiversity and ecosystem function by essentially keeping ecological processes in place similar to the ones that shaped most of the ecosystems in the continent. In the last century, however, available cheap energy and associated agricultural inputs, and plummeting agriculture commodity prices, caused the disappearance of many transhumant systems, competitively displaced by a model of industrial agriculture and livestock with high level of external inputs yet reduced wage costs. The Common Agricultural Policy of the EU, with increased productivity as main target – the school of thought in veterinarian and agronomical faculties – further deepens the problem. In the last decades, however, several factors have contributed to a push for recovery of sustainable land uses. Societal concerns about human-mediated global change are combined with a higher sensitivity for environmental issues, while the progressive exhaustion of cheap fossil energy sources drives to higher profitability of farming systems that do not need excessive external inputs. The transdisciplinary study of traditional transhumant systems sheds light on factors that drive sustainability. It orients the design of livestock systems that fit into a modern world, including demands for full integration of pastoralists in the contemporary society. But it also puts ancient sustainability elements, refined during a fossil fuel free evolutionary history, into the livestock production systems of the future.

Reindeer herders – the pastoralists of the north - challenges in a changing environment - a Fennoscandian perspective

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Reindeer pastoralism plays an central role for northern people throughout Eurasia. In Fennoscandia, Sami as well as ethnic Finns are engaged. The reindeer herding area in northern Fennoscandia covers ~500,000 km2, today stocked with a winter population of around ~650,000 animals, equally distributed between Norway, Sweden and Finland. It encompasses a gradient from semi-nomadic lifestyle to sedentary farming, mainly based on market-based meat production. Northern Fennoscandia experiences the combined impacts of accelerating environmental change and resource extraction, challenging the sustainability of reindeer pastoralism. Indeed, land-use conflicts, including conservation of large predators, and climate change challenge the herders' livelihood. Traditionally the system was based on seasonal pasture rotation. In recent decades, winter feeding has gained momentum in Finland and is spreading into Sweden and Norway as winter ranges have deteriorated the last decades driven by increased human activity and disturbance, high animal density and more frequent extreme winter weather events. Indeed, reindeer pastoralism based on intensive winter feeding represents a game changer with far reaching consequences. Many herders feel ensnared in a winter-feeding trap and would prefer, if possible, to rely on natural winter pastures. Functional ranges where the herds are allowed to graze undisturbed are therefore fundamental. This will enable reindeer pastoralism to thrive on natural ranges. Although Fennoscandian reindeer pastoralism is one of the most viable form of pastoralism in Europe, there is a need to provide herders and herding communities with real opportunities to decide over their pasture resources.

Prediction of reindeer herd productivity using weather-related variables and Normalized Difference Vegetation Index

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Reindeer husbandry relies on the natural pastures and is a vital part of the Sámi culture and livelihood. The ability for reindeer to survive and reproduce on these ranges is highly influenced by various weather events and access to food. Reindeer growth mainly depends on the summer grazing conditions such as vegetation productivity, insect harassment and weather. In our study we aimed at defining specific environmental conditions to predict reindeer herd productivity. We gathered data on female reindeer reproductive outcome and live weight of calves in summer and autumn, recorded by the herders in the Ruvhten Sijte Sámi reindeer herding community in Sweden between 2000 and 2021. Based on calve weights, two generalized additive mixed models were employed, i) with calf autumn weight (12001 obs), ii) with calf daily summer growth (5939 obs) as response variable, and precipitation, temperature and an insect harassment index acquired from the Copernicus spatial program as independent variables. To assess the effect of grazing resources we used the Normalized Vegetation Index (NDVI) from the Moderate Resolution Imaging Spectroradiometer (MODIS). The impact of calving in the preceding year on the current calf and the herd size effect were included as fixed effects. In both models we incorporated the calf's mother as a random effect and the age of the mother fitted with a smoother. Our results showed that both daily growth and autumn weight were positively affected by grazing resources while increase in insect harassment decreased daily growth, and increase in herd size decreased both growth and weight. The condition of the mother determined the weight of the calf but not its capacity to gain energy and fat in summer. Predicting herd productivity based on weather conditions and forage availability is essential for formulating management strategies in Sámi reindeer husbandry to address effects of climate change.

Altitude's influence on management practices and sustainability in alpine dairy farms: a case study of Aosta Valley, NW Italy

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Concerns regarding the sustainability of farms located at higher altitudes prompt an investigation into husbandry practices on alpine dairy farms across varying altitudes in Aosta Valley, NW Italy. Forty-two farms (around 30 lactating cows, vertical transhumance) underwent classification based on altitude: low (<599 m a.s.l., n = 14), medium (600 to 950 m a.s.l., n = 15), and high (>950 m a.s.l., n = 13). Farmers were interviewed regarding herd traits and management practices (nutrition, housing, and milk use). Data encompassed in-stall management during winter and summer pasture seasons. Common traits among the 3 altitude groups included tie-stall housing, predominance of dual-purpose Aosta Red Pied breed, calving from Dec to Mar, and milk mainly delivered to dairy cooperatives. Winter feeding consisted of hay and limited concentrate (F:C, 75:25), daily milk yields of about 12.0 kg/head, and FE of around 0.85. During summer, herds grazed at higher pastures (1,500 to 2,300 m) for 120 to 140 days, with diets based on grazing and limited (≤1.3 kg/head×day) compound feed. The high-altitude group exhibited higher milk fat content (36 g/kg) in winter, increased daily milk yield in summer (8 kg/head), but lower milk N efficiency compared to the other groups. Feed-food competition did not vary among altitude groups but between seasons, with pasture cows producing more human-edible proteins and energy than they consumed. In conclusion, while few differences were noted among altitude groups, the findings suggest that management decisions extend beyond altitude and can significantly impact the sustainability of dairy farming in mountainous regions

Pastoralism in France: what research agenda in view of the international year of rangelands and pastoralists (2026)?

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As part of preparation for the 2026 International Year of Rangelands and Pastoralists, an INRAE network of researchers from different disciplines synthetize the knowledge produced on French pastoral situations, and discuss their future under climatic and socio-economic changes. They propose an open definition of "pastoralism rearing". Based on grazing spontaneous vegetation, it encompasses various situations due to the diversity of vegetations and their part in feeding herds. Several issues are highlighted. Managing a diversity of food resources under strong climatic hazards is constitutive of these systems, generating particular rearing practices like mobility and choice of breeds, know-how and lifestyles. Quality signs and short value chains valorize their naturality. The multi-use of the grassland and rangelands raise ecological and local development challenges. All of this illustrate the diversity of the objects involved, constituting a specific system human – animal – nature – risks. Several research questions form an agenda : i) which sustainability of pastoral farms, how evaluate their multifunctionality? ii) how function the animal and pastoral resources notably to climate change? iii) which integration in territories and sectors? iv) which transformation of trades, know-how, working conditions, for renewing farmers and sheperds? v) how collecting and analyzing specific data and how developing digital tools and original devices? For all, interdisciplinarity and transdisciplinarity is at stake.

Timing of parturition in (semi) domestic reindeer herds and their reproductive success along an environmental gradient - insights from measures of plant phenology

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Concerns have arisen regarding the ability of (semi) domestic reindeer to adapt and adjust to the ongoing climate change. To investigate this, we conducted a study spanning three years (2009-11) across 13 reindeer herds in Norway, covering an extensive environmental gradient. We employed a logistic model to estimate herd- and year-specific peak parturition dates and synchronicity and calving success. Plant phenology measures were based on satellite infra-red spectrum. We explored the relationships between these reproductive measures and environmental conditions, including 1) spring occurrence and 2) winter conditions without time lags (t). We used lagged (t-1) measures of 3) maximum greenness, 4) autumn occurrence (autumn browning). Parturition date was positively related to spring green-up at their calving ground, negatively related to the lagged effect of autumn occurrence, max greenness, and autumn browning. We conclude that the herds' timing of parturition is adapted to local environmental conditions. Further, the date of parturition is modified by between-year and intra-annual seasonal temporal variation in forage quality, quantity, and accessibility, indirectly influencing females' body condition around mating and in late pregnancy which is known to impact date of conception and gestation length, respectively. The herds' high calving success, irrespectively of mean and between-year and intra-annual seasonal temporal variation in the phenological measures tested and winter snow conditions during late pregnancy suggests that they can tackle the ongoing climate change. However, the adaptive and plastic capacity of (semi) domestic reindeer may be at risk if the global warming in the north accelerates even further.

Transhumance and shepherd training: Knowledge transfer to maintain alpine pastoralisme

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In Switzerland, transhumance finds its importance through the summering cycle in the mountain area and the winter pastures in the Central Plateau and Jura. As far as summering is concerned, cattle have always been the decisive factor. But small ruminants have often been an important supplement. The shepherds of the pre-Alpine region were the ones who embodied the pride of the alpine agriculture with cattle, while sheep played only a marginal role. The importance of shepherds is increasing again, as improved pasture management and the presence of large carnivores pose new challenges. At the same time, the lack of competent shepherds and thus the need for specialised training has become obvious. With the organisation of the annual training courses for shepherd, AGRIDEA started to reinvent the Swiss Shepherd culture with the aim to improve the quality of flock management and the maintaining of the alpine grazing areas in Switzerland. Since 2009 more than 300 persons participated to the training courses. Not all the participants are going to work as shepherd, but most of them were working one season on the job. Only a few continue for more than 5 years with the work as a shepherd. The quality of the work has been improved in general, the management of the flock also. The transfer of experience and knowledge could be organized between old shepherds and the new young shepherd generation. But the fluctuation is very high because the working conditions didn't really improve although the salaries rose in general thanks to increased subsidies. The challenges in the pastoral profession have grown and the social conditions have changed. It is difficult to achieve continuity in the pastoral staff. In addition to correct wages, it is also necessary to improve the infrastructure and to shape the working conditions in such a way that pastoral employment becomes even more attractive. There is still an interest in training among young people. This must be used so that the pastoralist culture can be further developed for a sustainable maintaining of the alpine farms. The very heterogeneous backgrounds of the new shepherd generation are a very fruitful, inspiring but also challenging context for the further organization of shepherd trainings and the knowledge transfer in the agricultural education network.

Mountain forage production for sustainable ruminant systems in a context of climate change

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Mountain ruminant production systems are based on grassland, especially permanent grassland. Long winter periods require important indoor feeding of conserved grass as hay or silage. Climate change is already affecting grass production and the distribution of available forage resources throughout the year. Grass growth may often be reduced in spring and summer, but new opportunities for grass use may arise in autumn and even winter. Plant phenology is advanced in spring, with earlier heading dates, meaning that harvesting must be brought forward, which can be difficult in periods of frequent rainfall. Faced with these challenges, there are several levers to adapt existing resources or develop new ones. They are based on the adaptation of grassland management, taking advantage of the diversity of grasslands between plots that are more or less early, especially if they are at different altitudes. The introduction of climate-resilient species (resource-conserving grasses, Mediterranean legumes, diverse plants such as chicory, etc.), cereal-legume intercrops, summer catch crops and C4 photosynthetic plants can be considered on cultivated grasslands and plots. The development of agroforestry is also a way of providing additional forage resources during periods of low grass growth, as well as providing shaded areas for animals during heat waves. At the level of the forage and livestock system, the current and future climate means that more forage stocks will have to be built up to get through dry summer periods, or even structural changes will have to be made to reduce stocking rates.

Hay rich in water-soluble carbohydrates increases performance of dairy cows, irrespective of starch degradability supplementation

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Water-soluble carbohydrate (WSC)-rich forages can increase the voluntary dry matter intake (DMI) of dairy cows and diet digestibility, often resulting in higher dairy performance. Most studies have been conducted at pasture or with alfalfa hay and little is known on natural grasslands hay and on the interactions between forage WSC and concentrate starch degradability on dairy performance. We aimed testing the effect on dairy cow performance of botanically diversified grasslands hay (rich or poor in WSC) and its possible interactions with concentrate starch degradation rate (low or high). Four equivalent groups of 14 Holstein and Montbéliarde cows, were fed for 9 week 4.8 kg DM/day of concentrate, 3 kg DM/day of 2nd cut hay and a high (WSC+) or low (WSC-) WSC content1st cut hay (ad libitum). One group per 1st cut hay type received a barley meal based (D+) and the other group received a corn meal based (D-) concentrate. The WSC+ cows ingested more WSC (+551 g/day) and had a higher WSC/crude protein ratio (+0.24) than WSC- cows. The resulting higher OM total tract apparent digestibility (+2.1%) of ingested diet improved milk (+1.4 kg/day) and fat (+58 g/day) yields and feed conversion efficiency (+0.05 g milk/kg DMI) of WSC+ compared to WSC- cows. The WSC+ hay diet induced lower milk urea (-91 mg/kg) and higher milk protein content (+1.1 g/kg) and yield (+59 g/day) compared to WSC-. The effect of concentrate starch degradation rate on dairy performance was not significant for either the WSC+ or WSC- diet.

Unlocking the potential of Highland cattle: woody plant consumption and feeding preferences in encroached pastures in the Alps

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Since the 1950s, European mountain open areas have experienced significant woody encroachment due to agro-pastoral abandonment, posing critical challenges for extensive farming systems. Robust breeds like Highland cattle offer nowadays a promising solution due to their low maintenance needs, grazing adaptability, and agility on rough terrain. However, their foraging behavior in such environments remains understudied. This research examined the diet composition and feeding preferences of Highland cattle across four diverse woody-encroached pastures in the Western Alps. According to 11286 direct observations, cattle showed a major consumption (15-46%) of woody plants (more than 30 tree and shrub species), pointing out their potential as valuable forage resources. Jacob's Selectivity Index highlighted clear preferences for certain woody species, such as Celtis australis, Frangula alnus, and Rhamnus alpinus, while others like Corylus avellana, Prunus spinosa, and Sorbus aria were avoided. Remarkably, the relationship between species consumption and their abundance in the environment varied based on preference index, with preferred species consumed even at low abundance and avoided ones consumed mainly at high abundance. The noteworthy consumption of woody plants by Highland cattle, coupled with their resistance to cold weather and low demand for veterinary assistance, suggests their suitability for managing woody-encroached mountain pastures. Harnessing the potential of Highland cattle in marginal mountain areas holds promise for sustainable land use practices in the view of targeted silvo-pastoral systems in the Alps.

Assessing the agroecological management of grassland-based farming systems in mountain area through indicators

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In mountain area, traditional grassland-based farming systems provide different ecosystem services and a part of them can be considered as agroecological production systems. Several indicators can be used to assess the extent to which these production systems are agroecological. However, currently there is a lack of consensus among experts as to which indicators and tools should be used. The aim of this project is to test indicators at farm level to assess the extent to which a farming system is in agroecology. Thus, we collected quantitative and qualitative data in 10 farms involving ruminants in the Regional Park Livradois-Forez (France), including social and economic data to eventually propose an agroecological multicriteria approach. The surveyed farms have an average utilized agricultural area (UAA) of 62.70±28.67 ha and are composed by at least 80% of grasslands. Preliminary results suggest that economic data are the hardest to collect and are not always considered as the most important from farmers. On the other hand, the agroecological management of grassland-based farms highlighted a percentage of 93.35±5.66 of on-farm self-sufficiency. Nevertheless, farmers' perception is to have a gap of knowledge when it comes to grasslands management, and that they are adapting to social and environmental challenges. These results will contribute to the study of the reliability of the collected indicators and will increase the understanding of the agroecological level of a certain grassland-based farming system. Delving into this approach can drive the transition to an increasingly agroecological management through reliable and easy-to-gather indicators.

Regulating unwanted plants on mountain pastures by good pasture management

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Good fodder plants are the basis of sustainable mountain farming. Unwanted plant species have low fodder quality and some are poisonous for grazing livestock. Unfortunately, the knowledge on how to regulate these plants is usually passed on only orally. We aimed at gathering knowledge about relevant weeds and shrubs in mountain pastures and make it easy accessible online. Therefore, we conducted a survey among experts from science, advisory services, nature conservation and agricultural practice, and added available literature. Although there is no one-size-fits-all solution for all plants, we found several broad lines: (1) if individual plants are regulated at an early stage of establishment, the effort required is relatively low. Over time, they develop into a problem that can only be solved by much stronger efforts. (2) Many unwanted plants benefit from disturbances. A dense grass sward slows down the spread of unwanted plants. (3) There are hardly any selective herbicides for relevant weeds in mountain areas and the use of broad-spectrum herbicides creates gaps that are recolonized by weeds again. (4) Most unwanted plants are either promoted by over- or undergrazing. Thus, site-adapted grazing management is the most efficient way of regulation. This includes appropriate grazing pressure, timing and suitable grazing animals. (5) Any regulatory intervention only makes sense if the causes (over- or undergrazing) are eliminated through adapted grazing management. (6) Unwanted plants are persistent and persevering, due to e.g., underground storage organs, high regeneration ability, rapid spread, etc. Successful regulation is not a one-off measure, but means to be more persistent than the weed.

Forage qualitative investigation of mountain pastures in northern Italy

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Mountain pastures are essential for ecosystem services, and their forage production has a significant role in the farm production system. An efficient use of these coenoses could make up for the losses that other crops suffer due to climate changes. This study aimed to perform a vegetation mapping of the pasture in order to provide data for improving grazing methods and timing. The study was conducted during 2022 in two pastures (1800-2000 m a.s.l.) in the Paneveggio-Pale di San Martino natural park (Trento, Italy). Thirty-eight botanical surveys were carried out using the Daget-Poissonet method in June 2022 to map the vegetation of the two pastures. At each survey, herbage samples were collected in three harvesting periods (June, July, and August), and analyzed with the NIR spectroscopy method, based on robust calibration curves, to determine the chemical composition and calculate the UFL. The cluster analysis grouped the botanical surveys into: 1) vegetation characterized by Poa alpina and Crepis aurea (Poion alpinae), 2) vegetation characterized by Sesleria caerulea (Seslerion variae), and 3) a mixed vegetation of types 1 and 2. The NMDS analysis on herbage chemical composition, revealed a significant interaction between vegetation type and harvesting period. The herbage quality of type 1 vegetation was higher than other types, with a higher value in August than in June. In July, type 3 achieved a quality similar to type 1, with higher values in June. In conclusion, mapping the vegetation provided useful data for making decisions on type and timing of grazing to ensure a constantly balanced diet for the animals.

Socioeconomic and environmental sustainability of mountain farming

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Mountain livestock farms are coupled human-nature systems that provide many ecosystem services benefiting the wellbeing of society. We analyze the dynamics of mountain livestock systems in the Spanish Pyrenees in the last three decades through socioeconomic and environmental perspectives. From the socioeconomic perspective, we identified a general trend of evolution driven by the reforms of the Common Agricultural Policy. This trend implied farming structural changes (product orientation, agricultural area, labor reduction) together with an increasing dependence on public economic support to remain profitable. Additionally, we found different trajectories of evolution related to contrasting regional and household contexts. Farms from each valley studied adapted to regional limiting factors (agricultural area, tourism development and labor opportunities), and farms managed by elder farmers, with low formal education and dynamism presented lower adaptive capacity. From the environmental perspective, these changes implied sustainability improvements at the local scale (higher grazing period, lower dependence on purchased feeds), but lower overall sustainability given their reduced autonomy (high economic dependency and purchase of goods and services). Environmental accountability allows to consider all the work and resources that have been necessary to produce the goods and maintain the services that are lately purchased by farms, thus allocating to farms the environmental load associated with them. We argue that the often-alleged higher efficiency of industrial farming systems enhanced by dense feeds and high dependence on purchased inputs does not hold at the global scale given the embedded resources necessary to produce them, making mountain grazing systems a favorable alternative to reduce the dependence of livestock systems on fossil fuels.

Mountain sheep farming: a provider of environmental services

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In France, 85% of sheep farms are located in mountain areas. In these areas, livestock farming is usually the only possible economic activity and the only way to preserve grasslands. Sheep farming provides a wide range of services, particularly environmental ones: maintaining biodiversity, sequestering carbon, preserving water quality for the most important. One of the objectives of the LIFE GREEN SHEEP project is to study these services. Furthermore, it aims at reducing the carbon footprint of sheep meat and sheep milk by 12% while ensuring farms' sustainability in 5 EU countries (France, Ireland, Italy, Spain, Romania). Data from 421 French sheep farms (257 meat and 164 dairy) representing various rearing systems located in mountain areas, the project provides a good overview of the contribution to maintain biodiversity, store carbon in soils and limit impacts on water quality of these systems. Preliminary results indicate a contribution to maintaining (ordinary) biodiversity of 2,1 and 1,4 eqha/ha for meat and dairy systems respectively. Moreover, mountain meat sheep farming helps to store 456 kg C/ha and 343 kg C/ha for dairy farms. It also limits nitrogen leaching, 12 and 32 kg N/ha for meat and dairy farms respectively, thanks to the use of grasslands and low use of inputs and mineral fertilizers. Compared with lowland systems, mountain systems contribute more to maintain biodiversity, store more carbon and leach less nitrogen. Finally, mountain sheep systems also help to regulate the climate by offsetting an average of 22% and 65% of GHG emissions for dairy and meat systems respectively.

Effects of the farm type on the environmental impact, animal welfare and plant biodiversity of dairy systems in the Eastern Alps

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This study aimed to assess the effects of farm type on the environmental impact (EI), animal welfare (AW) and plant biodiversity (BIO) of dairy systems typical of the Eastern Alps. Data originated from 49 farms (30±20 dairy cows, 18.0±4.3 kg fat- and protein-corrected milk – FPCM/cow/d). Farms were clustered in 3 types on the base of farm size, structure and feeding management Traditional Farms (TF), Modern Farms with Low (MF-LSR) and High (MF-HSR) Stocking Rates. The EI was evaluated with a Life Cycle Assessment, considering animal and manure management, feed production and use of bedding materials and energy sources (system boundaries), 1 kg FPCM and 1 m2 of land area (functional unit) and global warming and eutrophication potentials (impact categories). The AW included animal-based measures recorded (longevity, milk cell count, dystocia, downer cows) and observed (body condition score, lameness, udder cleanliness). The BIO included 3 plots per farm (meadows and pastures), with plant species and family richness recorded along linear transects. Clusters were used as fixed effect in a GLM to analyze the effect on milk yield (MY) and EI, AW, and BIO. MFs had greater MY than TF. Farm type influenced EI per m2 (higher impact in MFs than TF) but not EI per milk unit. None of the AW variables were affected by farm type. About BIO, MF-HSR showed the lowest plant species and family richness and the TF the greatest. In conclusion, the multi-criteria assessment of the dairy system evidenced a complex effect (synergies and trade-offs) of the farm intensity on the different aspects of livestock global sustainability, thus highlighting that single assessments could have undesirable effects.

Ecosystem services and life cycle assessment frameworks provide opposite evaluations of livestock farming systems

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Life cycle assessment (LCA) and ecosystem services assessment (ESA) are often used for environmental evaluation. LCA is commonly used to assess the negative environmental impacts of livestock farming systems (e.g. emissions of CO2-eq.), whereas ESA is used to assess their positive contributions such as the supply of regulating ecosystem services (e.g. pollination or erosion prevention). Here, we applied both frameworks to a selection of twelve contrasting French meat-production systems, including two ruminant species (sheep and cattle) and two monogastric species (chickens and pigs). The selection included a mountain pastoral sheep system. According to LCA, ruminant systems had more negative impacts than monogastric systems and for example, the production of one kg of human edible protein emitted in average 280 kg CO2-eq for ruminants, and 32 kg CO2-eq for monogastrics. The mountain pastoral system had the highest value with 356 kg CO2-eq. These results are due, in particular, to the emissions of methane during digestion processes of ruminants. Oppositely, ruminants can supply more regulating ecosystems services than monogastric systems. The mean respective scores related to these services were 2.42 and 1.15, and the mountain pastoral sheep system had the highest score (i.e. 3.10). These results are explained by the presence of semi-natural habitats such as grasslands in ruminant systems. Our results show the antagonism between the LCA and ESA results for meat production systems. They also show that using ESA together with LCA can provide a more complete and balanced assessment of extensive mountain pastoral systems.

Carbon stocks and milk yields in silvopastoral systems in the Andean Amazon region of Colombia

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It is necessary to understand how dairy farms could maintain adequate yields and carbon stocks simultaneously. We investigated technological factors, yield, and carbon stocks in Silvopastoral Systems (SPS) in the Sibundoy Valey, Andean Amazon region in Colombia. 10 farms with high, 10 medium, and 10 low SPS coverage were characterized. Technological factors were assessed on a scale from 0 to 26 adoption points. Milk yields were determined and corrected for fat and protein contents.Total carbon stock was determined aboveground (trees, leaf litter, and coarse deadwood) and belowground (roots and soil 0-20 cm deep) segments. The area of SPS on farms ranged between 2.7 ha (27%), 0.6 ha (6.0%), and 0.1 ha (1.1%) in high, medium, and low SPS coverage, respectively. Technological developments ranged from 11.70±0.83 to 14.27±0.96, and milk yields ranged from 3118.4±184.4 to 3694.2±241.3 kgFPCM·cow-¹, without significant differences. Carbon stocks in aboveground biomass were higher ($p>0.05$) in farms with high coverage (168.7±36.6 MgC) compared to those with medium (40.4±6.2 MgC) and low coverage (12.3±3.1 MgC). In all cases, between 50% and 80% of the carbon stored at the farm level was found in live fences (LF) of Eucalyptus globulus. Total carbon storage in SPS ranged widely from 194.5±13.8 MgC·ha-1 in LF of E. globulus to 73.2±8.6 MgC·ha-1 in open pastures and 65.8±4.4 MgC·ha-1 in LF of Alnus acuminata. Carbon stocks did not interfere with production performance in farms with intermediate technological levels.

Coupled evolution of land cover and extensive livestock in the Spanish Pyrenees

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Land abandonment and the decline of extensive livestock farming threaten the provision of ecosystem services in mountain areas. In recent decades, while extensive livestock farming has been sharply reduced, mountain areas traditionally covered by pastures and meadows have been replaced by shrub and forest areas, i.e. revegetation. Both processes are linked, and the Pyrenees constitute an example of it. The coupled evolution of revegetation and livestock farming has been studied in specific valleys, but broader studies are needed to analyse the joint evolution of livestock and land use. Our research contributes to fill this gap by studying the central Spanish Pyrenees using Geographical Information System approaches. Data were obtained from (1) regional livestock databases, from which we selected 895 sheep and 407 cattle farms, and (2) the CORINE land cover database, from which we selected 82 municipalities covering 1161976 hectares. We analysed three time periods (2007, 2012 and 2018) using QGIS software. We found that livestock units decreased by 9%, while pastures decreased by 45% and forests increased by 26%. Thus, our results indicate that livestock and land cover trends are coupled. Land cover change varies between locations, but some common patterns can be found across the region. This research highlights the role of extensive livestock in shaping mountain landscapes and the implications of its decline.

Variation of animal welfare in dairy and fattening beef European farms between lowland and mountain conditions

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Livestock products from mountain and/or extensive systems are perceived by consumers as more "natural", healthier, and more animal-friendly compared to lowland and/or intensive systems. This study investigates the welfare profile of cattle farms in Europe and the link with geographical location. Within the European project INTAQT, 70 dairy and 50 fattening beef farms across six European countries (France, Italy, Switzerland, Germany, The United Kingdom and Spain) from mountain and lowland areas and presenting various intensification level were interviewed for practices and assessed for animal welfare using the Assurwell tool. The analysis of animal-based measures (ABMs) outcomes showed no significant differences between mountain and lowland areas at the European level. However, in France, mountain dairy systems (Massif Central) exhibited higher rates of mastitis (22.8 ± 3.2% of cows with cell score > 400,000/ml over the last 3 months; $p = 0.03$) than lowland dairy systems (7.8 ± 2.6%), but less thin cows (8.1 ± 2.8% vs. 25.6 ± 2.2%; $p = 0.001$) and a trend toward lower mortality (3.2 ± 0.7% vs. 6.0 ± 1.4%; $p = 0.07$). In conclusion, cow welfare does not seem to differ between mountain and lowland areas except in France which could be linked to the presence of more rustic breeds in the French mountain farms which were sampled. To extend beyond geographical considerations, we will then study the variability of these ABMs due to the level of intensification and the practices of the cattle systems.

Exploring Perceptions and Demand for Sustainable Alpine Wool: A Survey of Consumers and Shepherds in the Lanzo Valley (N-W Italian Alps)

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This research focuses on enhancing the native alpine wool supply chain, with a specific focus on the Lanzo Valley, by investigating the perception of ecosystem services (ES) provided by sheep farming in the Alps and the potential demand for sustainable products from consumers. The research begins with the assumption that alpine wool is not only a natural and eco-friendly product but also embodies important values such as land management, local economic sustainability, promotion of artisan traditions, and environmental sustainability integrated into the production process. A consumer survey was conducted in Piedmont (N-W Italy) involving 400 individuals. A Principal Component Analysis was first performed on consumers' preferences indexes about ES. Then, a Cluster Analysis was conducted to analyse clusters' heterogeneity in wool supply-chain perception and preferences. Four different clusters were obtained with significant differences with respect to age, sensitivity to environmental issues, knowledge of the term "ecosystem services", perceptions of ES provided by raising sheep in the mountains, purchasing behaviours and orientations, the importance attached to different indicators of the comfort of a wool garment, and the factors that guide purchase choices of wool clothing and items. In addition, the study revealed the respondents' general trends concerning the most valued products in the wool supply chain and the factors that generally drive purchase choices of both wool home accessories and wool clothing items. Despite economic and management challenges, the results highlight a strong cultural identity among shepherds and a growing consumers' interest in sustainable local wool

The school of pastoralism in Italy (SNAP), outcomes of the initial experiences

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The SNAP was established as a project under the "Appia" Network, the Italian Network of Pastoralism. The project comprises sectoral thematic modules, methods, and content with a national/European orientation, organized according to the needs of the target audience of the schools, the training territory, and the interests of local stakeholders. The initial trial, known as the Young Shepherds School, was overseen by the Association "Riabitare l'Italia" (CREA), the National Rural Network, and several actors active in the Piedmont region (Agenform and NEMO). The Scientific Committee of the SNAP group also garnered interest from the Region of Sardinia, University of Sassari, and some stakeholders of the SNAP group, producing the first edition of the school in 2023. Additionally, a project was launched within the Life ShepForBio project in Tuscany (Italian Apennines). Similar initiatives are being planned in Sicily and other regions of Italy in 2024. The three school experiences involved around 40 young people, approximately 25 years old, evenly split between males and females, from across Italy, with high school diplomas and, in some cases, degrees, half of whom come from the pastoral sector and the others motivated by pastoral enterprise creation projects. The schools' interventions aimed to: (i) reevaluate the role of the shepherd, (ii) emphasize the positive environmental impact, (iii) generate greater demand on the national territory, particularly among young people, for a generational shift, while bringing innovation, (iv) increase job opportunities both through the inclusion of new professionals and new professionalisms in existing or new farms, and (v) improve efficiency, management, and economic stability of agricultural companies through a community of practice and an exchange of experiences

Animal-based welfare assessment in alpine dairy farms

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There is increasing concern among public opinion and decision-makers about livestock welfare issues. This study aimed to produce an overview of cows' welfare conditions in Italian alpine dairy farms by analyzing the animal based measures (ABM) that were assessed between 2022 and 2023 in 143 mountain farms (i.e., located above 600 m a.s.l.) by the Italian official method for livestock welfare assessment, named ClassyFarm and originating from the Welfare Quality® protocol. The ABM were scored into three levels (insufficient, adequate, and optimal) and considered: avoidance distance test, body condition score (BCS), animal cleanliness, integument lesions, lameness, geometric mean of bulk tank somatic cell count, number of treatments for clinical mastitis within a year, and mortality. Descriptive statistics were produced and differences between tied stalls (TS; n = 100) and loose housing (LH; n = 43) within levels for each item were tested by Chi-square. Overall, the optimal score was obtained by more than 80% of the farms for avoidance distance test, BCS, body cleanliness, integument lesions, lameness, and the two udder health parameters, and no insufficient scores were recorded for any of these items. Insufficient scores were recorded for cows' and calves' mortality in 6% and 3% of the farms, respectively, whereas more than 70% had optimal scores for mortality of cows, heifers, and calves. Only animal cleanliness and mortality differed between housing systems, with the former being better in LH farms and the latter in TS ones. Despite the current debate on supposed low animal welfare in small-scale and tied-stall farming systems, this study showed satisfactory animal welfare level in alpine dairy farms, regardless of the housing system.

Importance of the katuns, as particular characteristic of Montenegro, for its economy and society

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The aim of this paper is to present the livestock production at Montenegrin mountains areas, called katuns – temporary settlements where the agricultural households stay with livestock during the summer season, mostly for 4 to 5 months. According to data collected, in 2020 there were 1618 households (eligible for state subsidies), who regularly moved from their permanent settlements to the 'katuns', with a minimum of 5 Livestock Units. They owned 22,445 LU, mainly cattle and sheep, but to a lesser extent goats and horses too. The farmers produce local dairy and meat products, which are not only important by their nutritional and economic value; they represent cultural and historical identity of people from the katuns. In terms of households' incomes, dairy products are very important, price of 1 kg of ripened Skorup from ewe's milk reached 25€. Price of white brine cheese was about 5 €/kg. Most of the local breeds of sheep and cattle have been adapted over generations to satisfy needs of farmers in their local environment. The social dimension of the katuns is extremely important. According to our estimations, 8% of the Montenegrin farmers involved in this production system, 6.5 thousand people benefited directly from katuns, while 3.3 thousand people benefited indirectly, in total – close to ten thousand people benefited from the katuns. The katuns face many challenges; one of the first is abandonment of the vital rural workforce, second one is the infrastructure in the mountain areas, then social life is not attractive for younger generation, limited possibilities to launch rural tourism and accompanied services.

Phenolic compounds and forage quality affect methane production potential from Swiss alpine summer pastures

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Alpine summer pastures are of high biodiversity and cultural value, but tend to provide forage of higher fibre content and lesser digestibility than more intensively managed grassland. This, in turn, may lead to higher enteric methane emissions from ruminants grazing these pastures. On the other hand, the diverse vegetation may be rich in tannins and other phenolics that can decrease enteric methane emission. To investigate these relationships, we took botanical relevés and sampled first-growth herbage from a total of 45 alpine summer pastures in two years. These pastures represented nutrient-poor and nutrient-rich sites at different altitudes in regions spread across the Swiss Alps. We determined concentrations of neutral detergent fibre (NDF), total phenolics (TEP), total tannins (TT) and condensed tannins (CT) and assessed in-vitro methanogenesis using the Hohenheim Gas Test. Concentrations of all phenolics fractions varied greatly between sites and were negatively correlated with NDF. With increasing NDF concentration, total methane production decreased but methane production per ml gas increased. By contrast, increasing concentrations of TEP, TT and CT led to decreases in both total methane production and methane production per ml gas. Our results indicate that phenolics in the herbage of alpine summer pastures may help to reduce the methane production potential of the ruminants that graze there.

Facing the change: assessing dairy farmers' responses to a potential tie-stall ban in the context of Northern Italy

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Tie-stall systems for dairy cows are scrutinised by public opinion because of welfare issues, mainly regarding limited social interaction and movement. However, this housing type is still present in Northern Italy, especially in the Alpine area, and is mainly used by small family farms. This study explores the potential impact of the ”End the cage age” ban (a component of European Strategy 2023) on dairy farms adopting a tie-stall system through a questionnaire distributed to dairy farmers in the Veneto region. The survey included questions about the farmer’s profile, the gross income and investments made, and the main obstacles encountered in changing their housing system. Among the total 245 questionnaires distributed, 218 were filled out correctly. Questionnaires came from 71 farms in the mountains (>500 msl), 39 in the hills (200-500 msl) and 108 in the lowlands (<200 msl). The average age of the owners was 52.7 years, and they were predominantly male (187). Most had a secondary education (109) and more than 30 years of farming experience (135). The intention of farmers to switch spontaneously to a free stall housing system was measured using a score scale from reluctance (1) to high willingness (10). It was relatively low, on average 3.1 ± 2.9 (SD). In particular, 128 farmers did not intend to change, while only 27 showed a high willingness (score≥8). The desire to convert their housing was significantly higher ($P<0.01$) for young owners (<45 years of age), those having a large herd size (>44 animals), a gross income of >100.000 € and owning >50 ha of used agricultural area. Elderly farmers were strongly inclined to maintain the tie-stall system until its prohibition, mainly due to concerns about the inability to secure succession after their tenure. In conclusion, imposing a ban on tie-stall dairy barns could lead to the cessation of activity for many small farms in Northern Italy unless they receive adequate workforce or technical and financial support measures.

How can sustainability of Norwegian sheep farming be improved?

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Livestock production systems with ruminants are generally associated with high enteric methane emissions and thus a high carbon footprint, causing these systems to be challenged when it comes to what products to eat and wear in a sustainable future. We aim to provide new knowledge and insight on how the sustainability of sheep farming can be improved with respect to food and fibre production, and how stakeholders in the value chain can enhance value creation in a wide sense. We assess the sustainability of Norwegian sheep farming through different methods such as the SMART-Farm tool (https://www.fibl.org/en/themes/smart-en), Live Cycle Assessment (LCA), human edible protein ratio calculations and farm profitability assessments. Further, consumer perspectives on how they understand products, meat, and wool, from sheep farming is assessed. A rationale for the selected methods to assess sheep farming will be presented, as well as preliminary results on factors affecting indicators of sustainability. Preliminary results show that sheep farming score high on different sustainability dimensions when assessed through the SMART-Farm tool. LCA needs to also include carbon sequestration for a more well-rounded assessment. Human protein edible ratio calculations show that results are highly impacted by concentrate feed, the levels of milk replacer used and lambs weaned in the autumn. Profitability in sheep farming is low.

Using sensors for mountain livestock research and management

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The past fifty years have seen a great advancement in the use of sensors in agriculture and our daily life. While most devices are still operating stationary and in-house, biologging systems directly carried by the animals offer opportunities to assess behaviour and health status of individual animals more closely also in outdoor environments. Moreover, airborne sensor systems inform about ecosystem status and structure in near real time. Knowing where animals are, what they do and which conditions they encounter, allows mountain farmers and researchers to better design sustainable livestock production systems. In this contribution, we focus on challenges, opportunities and other aspects to consider when using sensors in mountain livestock research and management. Based on examples from a market review and own experiences, we identify a number of challenges for sensor systems in mountain farming: (1) the diversity of livestock species and breeds for which the sensors are not calibrated, (2) the harsh environment and pronounced topography and (3) the complexity of data to be processed and analysed. On the other hand, animal-borne sensors offer new insights into mountain livestock behaviour and its effects on the environment.

Satellite images reveal variable growth patterns in mountain rangelands in response to annual weather variability

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Mountain pastures host a rich biodiversity organized in various distinct habitats. An accurate long-term monitoring, going beyond the sole ground survey, is of primary importance for nature conservation and forage production planning in the remote alpine zones. We use satellite images from the Sentinel-2 programme to track the growth season of mountain rangeland habitats over seven years (2016-2022), in relation to snow persistence and elevation changes. We consider as study zone the mid-to-high elevation mountain rangelands surrounding the Swiss National Park in the Grisons canton, Switzerland. The area spans over 1000 Km² including fertile pastures, wetlands, dry plant communities, and shrubs. We couple the ground classification to the NDVI spectral index to retrieve a proxy for living vegetation density and seasonal growth pattern. The habitats show a marked difference in their growth pattern in function of their wetness up to 2400 m a.s.l, while they seem to homogenize at higher elevation. In dry pastures and tall shrubs, growth appears to be strongly correlated to elevation. Growth in the first season half is controlled by snow persistence variations and partially compensated by a quick growth after snowmelt. Conversely, in the second half season, vegetation growth and persistence is statistically correlated to the NDVI peak. This workflow presents as an effective strategy to monitor the seasonal growth of mountain pastures and to analyse their spatiotemporal variability in response to annual weather fluctuations.

Implementation of virtual fencing in mountain conditions

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Virtual fencing (VF) has great potential to optimize pasture management. Thereby, animals wear a GPS collar that emits an audio tone (AT; rising pitch) when reaching a virtual boundary, followed by an electric pulse (EP; 0.2 J) when crossing it. VF can be beneficial in challenging mountain pasture terrain. The present study investigated whether VF is applicable under mountain conditions. 30 female heifers were fitted with a VF collar. After 2 weeks of VF training in the lowlands, the heifers were moved to a mountain summer pasture (1300-1500 m a.s.l.),divided into 3 electrically and 6 virtually fenced paddocks. Heifers were split into 3 homogeneous groups, balanced for age and breed. During 83 d, all groups grazed simultaneously in separate paddocks and rotated through the 9 paddocks. We found that the VF system worked reliably in mountain conditions, but required careful handling. Each animal received an average of 4.9 ± 6.9 ATs and 0.3 ± 0.7 EPs per day. Generalized mixed effects models revealed that the number of ATs and EPs did not change significantly after paddock change or during the course of mountain grazing. However, number of ATs and EPs increased with lower forage availability ($p < 0.01$) and on days when wildlife or neighboring cattle were present ($p < 0.001$). The VF system was effective in keeping heifers in their assigned paddocks. Therefore, VF has the potential to improve mountain pasture management.

Monitoring of animal behaviour in alpine pasture by digital systems

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Mountain grazing offers excellent opportunities for enhancing cow welfare through natural nutrition, extensive freedom of movement, and engagement in species-specific behaviors. In our study, herds of milking cows from two different breeders were monitored during their summer stay in Alpe Andossi, a unique alpine fenceless pasture in Madesimo, Italy, spanning 200 hectares at altitudes between 1850-2050 meters. This area, recognized for its naturalistic importance, features a mosaic of calcareous, acidic soils and peatlands, resulting in highly diverse pastures (limestone pasture, lush pasture, and four types of Nardus grassland) and complex soil-vegetation patterns. The milk produced from these pastures has peculiar characteristics in terms of lipid composition and aromatic profile and is used to produce the characteristic PDO alpine cheese called 'Bitto'. Cow grazing behavior was monitored using accelerometer-equipped collars to quantify resting, feeding, and rumination periods, along with GPS sensors to track animal movements and grazing preferences based on pasture type. Data on animal behavior and location, differentiated by breed, birth year, and lactation cycle, were collected at 15-minute intervals. This methodology facilitated the identification of behaviors influenced by pasture type, phenological stage, weather conditions, herd membership, and breed (Holstein, Red Holstein and brown). Digital tools proved effective in assessing animal behavior and welfare in mountainous environments, emerging as potential indicators for pasture management and biomass utilization improvements. The use of such technologies also provides crucial support to address labor shortages.

GPS collar data from free ranging sheep in Norway: New knowledge for farmers, authorities and resesrchers

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About 45% of the land area of Norway can provide feed resources for grazing domestic ruminants and can be described as unfenced rangeland forest and mountain land. They provide summer grazing feed and it is estimated that this feed has a value of some NOK 1000 million annually. In general, these systems are considered to provide high levels of animal welfare as animals can express natural behaviour in. However, this is compromised by losses to predators as well as disease and accidents. A main challenge for sheep farmers is the supervision and guarding of these animals. This challenge is the background for the extensive implementation of GPS collars on grazing livestock in Norway in order to track animals during the grazing season. It is estimated that currently some 150 000 GPS collars are on sheep in Norway gand they are gathering about 100 million positions every year; with number of collars as well as quality and quantity data improving every year. The farm grazing group of Meråker beitelag consists of 25 farmers that graze some 2000 ewes with lambs every year. All ewes have GPS tracking collars and since 2019 position data are gathered every 4th hour throughout the grazing season. A large proportion of the farmers also use the Norwegian Sheep Recording System (NSRS) for farm management, where performance, pedigree and health data is recorded. Merging GPS data with performance data from NSRS allows the study of numerous factors in the development of Early Warning Systems (EWS) related sheep health and welfare (i.e. suvailance of mastitis, other disease, predators, climate, vegetation etc). Also, land use knowledge is important in a future of increasing multi interest conflicts from the society in these areas (i.e. cabins, hiking, hunting, windmills etc.).

Cost-benefit analysis of digital and precision livestock farming technologies for sheep and goat farms

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Sm@RT is a EU Horizon 2020 funded project, involving 8 countries, which aims to encourage technology uptake by sheep and goats farmers. In a series of national and international workshops, farmers identified 166 different needs and challenges regarding technology use on their farms. Sixty potential solutions were collated and proposed to farmers, who voted to retain 30 different technologies across the sheep (meat and dairy) and goat (dairy) industries; each subsequently had a cost-benefit analysis (CBA) undertaken. For context, each CBA was based on a benchmark farm. Information on initial set-up and running costs of each technology, training requirements and potential benefits were collated. An overall summary included an ease-of-use scale, information on value for money, and a recommendation for different types of sheep and goat farms. These CBAs enable farmers to assess objectively whether a technology is appropriate for their farm needs, system and budget. The impact of using each technology is highlighted by the range of potential benefits associated with social, environmental and welfare topics. Benefits relating to flock management, labour efficiency and animal welfare were evident for many of the solutions proposed.

Sm@rt project: Update on evaluation of innovative technologies by sheep and goat farmers

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Sm@RT (Sm@ll Ruminant Technology) is a EU Horizon 2020 funded thematic network, involving 8 countries, aiming at encouraging the uptake of technology on small ruminant farms. The best innovative technologies were selected in each country and evaluated by sheep and goat farmers at 2 different levels: Training sessions (Digi-farms, research center), from researchers to farmers, and Demonstration days (Innovative Farms, commercial farms), from farmer to farmer, in order to provide tangible knowhow on practice and to allow the farmers to see, experience and understand in practice how the different technologies work on farms. Farmers attending the events completed questionnaires before and after evaluating a technology, to gauge if their opinions changed after the sessions. During these events, the cost benefit analysis of technologies was also presented. The results and feedback of farmers' evaluations were summarized for each country. For some technology, farmer's opinion changed after the training. For most of the technologies evaluated, farmers thought that was worth investing and implementing them on their farms, probably for the moderate to high levels of practicality and economic value detected. Knowledge sharing from farmer to farmer in commercial farms has been a success. Digifarms remain a reference point for farmers who need to improve their knowledge of a specific technology

Characterisation of cattle habitat selection in mountain areas with GNSS tracking collars

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The determination of appropriate stocking rates is crucial for an effective livestock management in mountain areas, which often comprise high value ecosystems. However, the traditional use of stocking rate as a management tool assumes a homogeneous distribution of animals over grazing areas, which is not suited to the complex landscapes and the diversity of forage resources found in mountain areas. This study was carried out in Sierra Nevada Natural Park, Granada, Spain. GNSS collars were used to monitor cattle location at 30 min intervals. Fifty cows, from a total of 140, were monitored during two different six-month periods between 2018 and 2021. Habitat preferences were studied using Jacobs Selection Index (Jacobs, 1964), which was computed for each cow and day and for several landscape characteristics, such as slope, sun exposure, altitude, distance to water and vegetation status measured through the Normalised Difference Vegetation Index (NDVI). The results of the study revealed some patterns of habitat selection by cattle. In terms of slope, cattle showed a slight preference for lower slopes, while areas with steeper slopes tended to be avoided. In terms of sun exposure, cattle showed a slight preference for shaded areas over sunny areas. In this study, animals consistently avoided areas below 1900 m above sea level and above 2500 m. Distance to watercourses significantly influenced habitat selection, with a clear preference for areas within 250 metres of watercourses. Vegetation condition played an important role in habitat selection, with cattle avoiding areas with sparse or very dense vegetation. This study provides valuable insights into habitat selection patterns of cattle grazing mountain pastures.

BOVIEX 4.0: Technological Improvement in Extensive Cattle Production in Spain

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The BOVIEX 4.0 operational group was established with the aim of promoting innovation and digitalization in the livestock sector, specifically in the field of extensive cattle production. Regarding the preliminary results obtained, a study involving surveys in a total of 50 livestock farms that breed animals of pure Avileña Negra Ibérica and Asturiana de los Valles breeds, located in different autonomous communities of Spain. The surveys demonstrate that these farms vary in size, ranging from 100 to 3000 hectares. They also feature a grazing system that combines both pastures and dehesas, with an average livestock density of 0.55 livestock units per hectare. The data shows that 70% of the animals in these farms are breeding animals, while only 8% are destined for rearing. One significant finding in this study is the difficulty in detecting abortions, as 84% of the respondents are familiar with diseases causing reproductive failures such as BVD, trichomoniasis, or campylobacteriosis. Farmers do not monitor abortions because the animals are raised extensively in high mountain areas and extensive pastures, meaning that due to their management system, it is not feasible to perform serial ultrasounds on the animals. In general, the surveys highlight the need for specifically trained personnel in livestock matters, as well as the implementation of measures to stimulate young people's interest to promote generational turnover, incorporate digital tools to facilitate the daily work of the farmer with automation in data collection. Currently, animal welfare assessment is being carried out on these farms by collecting data associated with the four fundamental principles described by Welfare Quality, but with specific adaptations aimed at adjusting these principles to extensive production systems.

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