“Mountains are agroecosystems for people”

eBook of Abstracts of the 1st Joint Conference of

EAAP Mountain Livestock Farming Working Group

& FAO-CIHEAM Mountain Pastures Sub-Network

Virtual meeting

Domžale - Slovenia, 7 – 9 June 2021

Publishers:
University of Ljubljana, Biotechnical Faculty, Department of Animal Science, Domžale, Slovenia
University of Torino, Department of Agricultural, Forest and Food Sciences, Torino, Italy
University of Padova, Department of Animal Medicine, Production and Health, Legnaro (PD), Italy

Editors:
Giampiero Lombardi: Department of Agricultural, Forest and Food Sciences - University of Torino, Italy
Giulio Cozzi: Department of Animal Medicine, Production and Health - University of Padova, Italy
Marija Klopčič: Biotechnical Faculty, Department of Animal Science - University of Ljubljana, Slovenia

Year of publication: **2021**

All extented abstracts are reviewed by two independent reviewers selected from the Scientific Committee of the Conference

https://repozitorij.uni-lj.si/IzpisGradiva.php?id=127717

Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani

COBISS.SI-ID 72368387

ISBN 978-961-6204-78-1
(Biotechnical Faculty, Department of Animal Science, PDF)

Scientific programme

Management of mountain grassland in Slovenia

Vidrih M.[1], *Klopčič M.*[1]

[1] *Biotechnical Faculty, University of Ljubljana, Jamnikarjeva ulica 101, 1000 Ljubljana; matej.vidrih@bf.uni-lj.si*

Keywords: mountain grassland, abandonment, biodiversity, grazing, large carnivores

Nowadays in Slovenia permanent meadows and pastures with low stocking density still dominate the agricultural land use in mountainous and karstic regions. Dairy farming and suckler cows are still the most important agricultural sectors in that region followed by small ruminant breeding but the modern livestock husbandry systems have weakened the traditional strong link between farm in the valley and mountain pastures. Livestock farming in the Alpine region has changed so much (artificial insemination, rearing of more intensive cattle breeds, high producing animals, large imports of concentrate feeds) that the farm in the valley is no more dependent of mountain pastures for the summer grazing. How many farms are still focused on cattle breeding in the Alpine area, whose existence still depends on mountain pastures? Despite all the findings on the usefulness of the grazing practice in mountain pastures for livestock health, most of the replacing heifers for highly productive cows are kept and bred in the valley. If this dependence still exists, then the same number of valley farms would have collapsed as the mountain pastures have now collapsed.

For the needs of today, it will probably be necessary to redefine the concept of what a mountain or mountain pasture is, given the role that these grasslands have for the cultivated appearance of the landscape, quality of life of people living in the valley, sustainable farming, plant and animal biodiversity conservation and opportunities for recreation activities and tourism. Times have changed and the non-productive functions of these lands are becoming increasingly important. What are these non-productive functions of the mountains, we just have to agree and bring into the subconscious of as many people as possible on the sunny side of the Alps.

We must tell ourselves and everyone else that: - mountains are land where more than 150 different botanical species can be found on small piece of grassland; -mountains are the basis for feeding and conserving wild ruminants; -mountains are grassland areas where we can breathe fresh air; -a mountain is a grassy world where everybody can take off and land with kites, parachutes, hikers; are safe from a wolf and a bear (if the mountain is arranged for controlled grazing with an effective electric fence). In the mountain pastures city children can still see free domestic animals in their natural environment and learn about natural conditions in which our ancestors had to produce food 200 years ago in order to survive on the territory of today's Slovenia. Of course, if we preserve the mountains, we will also preserve their productive function, because today we can preserve the mountains only with the most natural and often the cheapest way of maintaining grasslands, by grazing domestic ruminants and horses. Doing this by organic farming for which it is known that supports agriculture in mountainous and karstic regions more environmentally and economically sustainable we might expect better future for our Alps.

Session 1: Farming systems and global change

Take home messages

from oral and poster presentations

Mountain dairy farming in North-West Italian Alps: comparing environmental, economic and social aspects

Blanc S., Verduna T., Merlino V. M., Cornale P., Battaglini L. M.

Sustainability of dairy farming in the alpine environment considering the environmental, economic and social aspects of the production of a typical cheese in north-western Italy.

An eco-citizen dairy farming system in mountain areas with the calves reared by their dams

Pomiès D., Bouchon M.

The mountain farming system designed within the Ladybug project makes it possible to conciliate milk production and suckling of male and female dairy calves, meeting the expectations of citizens on environment, healthy food and animal welfare.

Towards the climate change in Alpine pastures: perception of heat stress by dairy farmers

Lora I., Ammer S., Dohme-Meier F., Keil N., Cozzi G.

Although some signs of heat stress in grazing cows of alpine regions can be detected, Alpine farmers do not consider heat stress as a problem for their region. Actions should be taken soon to raise awareness of Alpine dairy farmers about the risks and consequences of heat stress in dairy cows.

Grazing strategies and their relationship to traits of milk performance testing in cattle

Fuerst-Waltl B., Musati M., Coppa M., Fuerst C., Ivemeyer S., Klopčič M., Martin B., Winckler C.

Across three countries, Austria, France and Slovenia, first lactation 305-yields of cows that were partially reared on extensive alpine, upland or Karst pastures were below those that were kept on home farms only. However, as access of young stock to mountain or extensive pastures may be beneficial with regard to fitness, next steps will include detailed analyses of functional traits.

The restoration of abandoned temperate forests with semi-free-range pigs: the experience of 'Food For Forest'

Nota G., Berretti R., Ravetto Enri S., Pittarello M., Barberis D., Ascoli D., Motta R., Lombardi G., Battaglini L. M., Lonati M.

The project 'Food for Forest' proposes a multifunctional silvopastoral system with semi-free-range pigs for the restoration of abandoned temperate forests. This management approach can enhance the ecosystem services while providing a sustainable meat product for the market.

Cattle breed – an underestimated driver of mountain pasture management

Pauler C. M., Isselstein J., Bérard J., Schneider M. K.

Cattle breeds differ in terms of anatomy, movement and foraging behaviour, with far-reaching consequences for pasture vegetation. The less productive a breed is the more evenly it moves and forages. Low-productive breeds have a positive influence on species richness of marginal mountain pastures.

Beef livestock system in a silvopastoral area of Sardinia

Acciaro M., Manca C., Marrosu M., Sitzia M.

The Mediterranean silvopastoral areas can support the production of grass-beef and the livestock activities, at moderate stocking density, and, thanks to the human presence, the conservation of the ecosystem services that these areas provide.

Environmental sustainability of summer grazing or no summer grazing farming systems in a Lombardy alpine valley: two case studies

Gislon G., Chiaravalli M., Colombini S., Bava L.

The comparison among traditional summer grazing and more intensive dairy farms shows that the low milk production of the first one penalized some environmental impact categories but the low use of input reduces climate change per unit of milk and potentially human-edible gross energy conversion ratio.

Do beef cows reared on mountain pastures of central Spain need to be supplemented?

Lobón S., Joy M., Casasús I., Casado P., Torres C., Blanco M., Sanz A.

The study was carried out in a mountain farm. Samples of the pastures where cows were grazing at the time of sampling were collected to evaluate the quality. The results showed that the quality of forage was enough to maintain the herd without supplement during half of the year.

Nitrogen farm balance and efficiency in mountain dairy farms

Tamburini A., Gislon G., Bava L., Zucali M., Sandrucci A.

The study showed poor sustainability characteristics of dairy farming systems in the considered Lombardy mountain area, particularly in terms of low feed self-sufficiency, high stocking density and, in a number of cases, high farm N balance.

Systems biology approach to study high-altitude genetic adaptation in Bosnian mountain horse

Zorc M., Ferme T., Horvat T., Mesarič M., Dovč P.

Studying the genetic background of high-altitude adaptive mechanisms can contribute to improvement of genomic characterisation of livestock breeds which plays an important role in planning conservation measures and management of animal genetic resources.

Effect of the sainfoin preservation on the secondary compounds and antioxidant activity

Joy M., Rufino-Moya P. J., Bertolín J. R., Lobón S., Blanco M.

The aim was to evaluate how the preservation method affected the contents of the secondary compounds and AO activity. The preservation method greatly affected most of contents. Further studies are required to assess the effects of all these changes on the impact on the quality of the animal product.

Grassland-based farming systems in Europe

Newell Price J.P.[1], *Ravetto Enri S.*[2], *Lombardi G.*[2], *Schils R.*[3], *Berge H. ten*[3]

[1] *ADAS, United Kingdom,* [2] *Department of Agricultural, Forest and Food Sciences, University of Torino, Italy,* [3] *Agrosystems Research, Wageningen Plant Research, Wageningen, The Netherlands; Paul.Newell-Price@adas.co.uk*

Keywords: grassland, farming systems, sustainability

This paper considers the importance of permanent grassland (PG) in Europe in terms of its area and extent and the range of ecosystem services (ES) it provides. We then consider what elements determine whether or not any particular grazing livestock farming system is sustainable in the 21st century, within the context of global change and current threats to permanent grassland. Finally, we used farm accountancy data network (FADN) data to characterise how farming systems with PG vary across Europe in terms of the dominant livestock types, stocking rates, the share of PG and the exploitation regime.

PG is defined as "any land dominated by grasses or herbaceous forage that can be grazed/mown and has not been included in the crop rotation of a holding for five years or more". According to Eurostat data for 2018, PG covered almost 60 million hectares across the EU-27+UK and accounted for 34% of the total Utilised Agricultural Area (UAA) (Eurostat 2021), although there are large differences between countries in terms of proportion of UAA, spatial fragmentation and distribution. This results in contrasting priorities in terms of the specific roles played by PG in different countries and regions.

Permanent grasslands support social infrastructure and high levels of biodiversity that in turn can enhance ecosystem function and value to society (Cardinale et al., 2012). PG are also the basis for many highly valued landscapes and offer recreational potential in many regions. The ability of farmers and land owners/managers to maintain and manage grasslands for ES delivery depends on local conditions (including soil type, slope and prevailing weather conditions), farm type (e.g. dairy, beef, sheep, goat), the profitability of the farming business and any financial support/incentive provided by rural development programmes.

Grazing livestock farming systems, which often include a significant proportion of PG, produce food products and other services that contribute to a balanced and nutritious diet (Salter, 2017) and support vibrant rural communities. In order for these systems to be environmentally, economically and socially sustainable they cannot be reliant on imported concentrates and feeds, thereby minimising their overall carbon and land footprint; and supporting biodiversity on and off the farm. They must also be resilient to climate change and receive a fair price for the produce and the range of environmental services they provide. At an appropriate scale and stocking rate, matching production to the carrying capacity of the land, they can help meet current climate (IPCC, 2019) and biodiversity (IPBES, 2019) challenges and contribute towards achieving many of the FAO Sustainable Development Goals (FAO, 2015).

However, PG is under threat from land use change, climate change, abandonment and intensification, resulting in a trend for a decrease in PG area across Europe. Across the EU-6 (Belgium, Denmark, Germany, France, Italy and Luxembourg), between 1970 and 2010, PG losses were estimated at around 30%, i.e. a loss of c.7 million ha (European communities, 2000 & Eurostat 2017). More recently from 2010 to 2013, the total area of PG across the EU-27+UK reduced by c.2% (i.e. c.1.3 million ha); with reductions in land area measured in most countries (Eurostat, 2017).

There is therefore variation across Europe in the importance of PG within farming systems, the dominance of different livestock species, stocking rates (generally higher in Atlantic regions and lower in Mediterranean and boreal regions) and exploitation regime in terms of whether grass is predominantly grazed or cut. EC FADN data and survey data from 352 European grassland-based farms indicate that farms dominated by beef cattle are more widespread than dairy farms and that the beef farms are generally associated with moderate stocking rates (0.5-1 LU/ha) and a significant proportion of PG on farm (50-70%). Dairy farms are associated with higher stocking rates (> 2 LU/ha), a lower proportion of PG (<10%) and predominantly cutting systems. Survey data gathered by the Horizon 2020 SUPER-*G* project (www.super-g.eu) will also provide information on the importance of imported feed in these systems.

In summary, PG are under threat in Europe, but are important within many livestock grazing systems. There is an urgent need to assess the sustainability of grassland-based farming systems, and to recognise and value the ES they provide, so that the right policies are put in place to support farming systems that provide net positive environmental services for society.

Mountain dairy farming in North-West Italian Alps: comparing environmental, economic and social aspects

Blanc S.[1], Verduna T.[1], Merlino V. M.[1], Cornale P.[1], Battaglini L. M.[1]*

[1] Department of Agricultural, Forest and Food Sciences, University of Turin, Grugliasco, Torino, Italy; simone.blanc@unito.it

Keywords: livestock farming systems; life cycle assessment; life cycle costing; human-edible feed conversion; mountain.

Introduction: Agriculture in general and livestock farming in particular are strategic to the economy. At the same time, they generate a growing debate for the social implications of resource use and food competition from livestock, which has one of the highest environmental impact amid productive activities in the European Union and leads to a reduction of edible crops for humans.
Aim of this work is to analyse the three concepts of sustainability (environmental, social and economic) applied to different dairy farming scenarios of the Alpine environment. In order to do so, the production of a traditional cheese (*Toma di Lanzo* cheese) obtained in a mountainous regions of Piedmont - North-Western Italy - was analysed.
Materials and methods: The case study used refers to dairy farms and the derived *Toma di Lanzo* cheese. The farms were selected to be a representative sample of the dairy sector in the Lanzo Valley in North-Western Alps of Italy. The dairy farms studied are family-run, generally with less than 100 dairy cows, and lead the herd to alpine pastures in summer. The cows' diet is based on pasture and conserved fodder, mainly hay, plus concentrates.
Four different scenarios were studied: Indoor Winter Feeding (IWF), Valley Bottom Grazing (VBG), Mountain Pasture Grazing (MPG) and Alpine Pasture Grazing (APG). For each scenario the grazing, milking, cheese making, and transport phases were analysed.
The methodologies used in the study were either the Life Cycle Assessment, to evaluate the environmental impact of each scenario and the Life Cycle Costing, to evaluate costs, profitability and human-edible feed conversion efficiency to evaluate feed-food competition.
Results: The study showed that the herd management systems mainly based on the use of summer pasture and exploitation of land resources (MPG and APG scenarios) guarantee a reduction of 47% of kg CO_2 equivalent emissions when compared to traditional high-input farming systems (IWF and VBG). Moreover, mountain farming systems guarantee a higher profitability of technical and economic factors used for the same output in the lowland environment (APG is 7 times more profitable than IWF).
With regard to food competition in livestock farming, which implies a reduction in the use of crops and feedstuffs edible by humans in the animals' diet, pasture systems and grass-based feeding systems are ones of the most sustainable ways to produce milk.
Conclusion: *Toma di Lanzo* cheese is an example of a sustainable production system, thanks to the use of mountain resources and the maximisation of the food conversion index offered by grazing.
It is clear that the existence and survival of mountain livestock systems depends on these, preferably autochthonous breeds, which have a positive impact on sustainability aspects such as biodiversity conservation
The economic results underline the importance of developing farming systems with a low percentage of off-farm inputs. Moreover, *Toma di Lanzo* cheese – which is highly dependent on alpine ecosystem resources - has a positive impact on the economic survival of these fragile areas, as well as on the maintenance of production traditions, clearly providing relevant ecosystem services.
In general, mountain livestock systems present several criticalities mainly linked to social factors and it's desirable an improvement in the quality of life of farmers and at the same time of the competitiveness of these enterprises.
Human indicators confirm that pasture and grass-based feeding systems are more sustainable in dairy production. Therefore, the reduction of concentrates, cereals and legumes, in the animal diets reduces food competition with humans and improves the sustainability of traditional dairy farming systems in the alpine regions.

An eco-citizen dairy farming system in mountain areas with the calves reared by their dams

Pomiès D. [1], *Bouchon M.* [2]

[1] *Univerité Clermont Auvergne, INRAE, VetAgro Sup, UMR Herbivores, F-63122 St-Genès-Champanelle, FR,* [2] *INRAE, UE Herbipôle, F-63122 St-Genès-Champanelle, France; dominique.pomies@inrae.fr*

Keywords: dairy cow; calf suckling; system experiment; milk production; calves' growth

Introduction: In a context of global change and growing distrust of livestock productions (Delanoue et al., 2018), mountain dairy farming has assets (landscape maintenance, social, cultural, economic) to promote. As part of a participative research project, we have designed and implemented an innovative farming system that meets the expectations of citizens on environment, healthy food and animal welfare, especially by allowing calves to suckle their dams until weaning. The aim of this study is to present some zootechnical results from the first year of the project.

Material and methods: A prototype of a low-input farm was imagined by a group of around 60 local dairy farmers, representatives of farmer groups, producer organizations, environmental organizations, agricultural schools, and researchers. Called "Ladybug", it was set up from spring 2020 in a mountain grassland area (1080 m asl) at INRAE Herbipôle facility (DOI: https://doi.org/10.15454/1.5572318050509348E12, 45.30°N, 2.84°E). The herd consists of 28 Holstein and Montbeliarde cows, and 16 one-year and two-year old heifers. The calving season (March 1 to May 15) occurs around turn out to pasture, in order to synchronise lactation curves with the grass growth. During 2020 winter and early spring, cows were fed hay and 2 kg/d of concentrates indoors, and grazed from May 4, and as long as possible during the rest of the year. During winter, cows are housed in a free-stall barn with cubicles, with an adjacent straw-bedded pen for calves. All calves, male and female, were suckled by their dams. From 9 AM to 5 PM calves had free access from their pen to the dams' barn; at night they remained together in their pen, where they could maintain visual contact with the dams. From the end of April, the calves followed their dams to pasture during the day. The 15 female calves were gradually weaned at 3 months of age using "nose-flaps", and were separated from the dams one week after the last weaning. The 12 male calves were suckled by their dams up to 4-6 months of age, and then sold all together for slaughter in the region. Until the separation of the female calves, the cows were milked once a day, in the morning.

Results: During the first 15 weeks of lactation, milk collected at parlour from Ladybug cows was on average 11.2 kg/d per cow, with a fat content of 29.0 g/kg, a protein content of 31.3 g/kg and a SCC of 292 000 cells/mL. We observed a maximum collection of 14.3 kg/d from week 3 to week 6, followed by a decrease and a stabilisation at 7.3 kg/d in the 13th week of lactation, when the female calves were gradually weaned. Compared statistically to a similar group of 27 cows, whose calves were separated at birth, Ladybug cows produced 14.4 kg/d less milk at parlour, with a 10.0 g/kg lower fat content, a 2.0 g/kg higher protein content, and the same SCC. This difference in milk yield is mainly due to 1/ the quantity drunk by the calves (about 11% of their BW, i.e. 10.7 kg/d on average over the period) and 2/ the diet of the "classic" cows (beet pulp + 5.0 kg/d of concentrate from calving to grazing; 1.5 kg/d of wrapped silage + 3.0 kg/d of concentrate at pasture), explaining a difference of about 3.2 kg/d. The lower fat content of the milk collected is mainly due to the calves' suckling, which benefits from the extraction of alveolar milk (richer in fat), as we hypothesised that suckling may induce a higher oxytocin response than milking. The higher protein content reflects a lower mobilization of body reserves after calving, confirmed by the fact that Ladybug cows recovered 20 kg more weight than other cows 15 weeks after calving. At 14 weeks of age, female calves suckled by their mothers weighed 15.6 kg more ($P = 0.062$) than those fed bulk milk by an automatic feeder (131.3 *vs* 115.7 kg). The better growth of future Ladybug heifers may be partly explained by ad libitum milk feeding until weaning, with milk richer in fat, and possibly by a more diversified diet due to access to pasture with the dams. As expected, the Ladybug male calves reared to be sold for slaughter grew faster than the females ($P = 0.028$), reaching a weight of 142.9 kg at 14 weeks.

Conclusion: The Ladybug system experiment will be piloted, regularly evaluated and improved for 5 years. Such mountain dairy systems, promoting dam-calf contact and meeting the environmental expectations of citizens, will only develop if their products benefit from higher prices, for example thanks to an "ethical milk and meat" label.

This research was financed by the French government IDEX-ISITE initiative 16-IDEX-0001 (CAP 20-25).

Towards the climate change in Alpine pastures: perception of heat stress by dairy farmers

Lora I.[1], Ammer S.[2], Dohme-Meier F.[3], Keil N.[4], Cozzi G.[1]

[1] Department of Animal Medicine, Production and Health, University of Padova, Viale dell'Università 16, Legnaro (Padova) 35020, Italy; [2] Department of Animal Sciences, Division of Livestock Systems, University of Göttingen, Germany; [3] Agroscope, Ruminant Research Unit, Posieux, Switzerland; [4] Federal Food Safety and Veterinary Office, Proper Housing of Ruminants and Pigs, Ettenhausen, Switzerland; isabella.lora@studenti.unipd.it

Keywords: Alpine pasture, heat stress, dairy cow, climate change

Introduction: Climate change is becoming more perceptible even in the Alpine region, where the possibility of extending the grazing season has already become a reality. However, besides these positive aspects, warmer environmental temperatures in the Alpine regions will bring new challenges to grazing dairy herds, such as the risk for heat stress. The highland of Asiago (north-eastern Italy) is located at 1,000 m a.s.l., and during the summer season hosts numerous local or transhumant dairy herds. In the grazing season of the year 2019 (from early June to the end of September), using the temperature-humidity index (THI) calculated on local official climatic data, it was found that cows were exposed to a risk of thermal discomfort (68 < THI < 72) for 37 days and to a risk of more severe heat stress (THI > 72, max = 79.9) for 44 days. The aim of this study was to find out how local Alpine dairy farmers perceived the problem of heat stress for their herds.
Materials and methods: A questionnaire was submitted through a direct interview to a voluntary sample of 25 dairy farmers of the area of the Asiago highland that used pasture grazing for their lactating cows from June to September in the year 2019. Part of the questions was about farm characteristics and herd management, and the other part focused on heat stress in cows. Questions dealing with heat stress were about the signs of heat stress observed in cows, the consequences on cow health and behaviour, and the actions that can be taken to mitigate it. For each of these questions, farmers had to rate each answer option from a predetermined list on a scale of scores ranging from 1 (less important) to 5 (highly important), with 3 as a neutral response. The interview was carried out during the Autumn and the farmers' answers regarded the grazing season that just ended.
Results: The distribution of the surveyed dairy herds according to the prevailing cattle breed (> 63% of the total cows) showed 12 farms rearing mainly Holstein cows, 4 farms with Brown cows, 3 farms with Simmental, and the remaining 6 farms a mix of these breeds. Overall, farmers did not consider heat stress as a relevant problem for their herds (score ± SD: 2.16±0.99) even though nearly half of them (n = 11) declared that some signals of heat stress were observed in their cows during the last summer. All these farmers reared mainly Holstein cows (75±11% of the herd) and detected heat stress based on a drop in milk yield (73%), reduced forage intake (55%) and cow activity, higher water intake, and search for shadow (45% each). An increased breath rate was reported by only 18% of the farmers that observed signals of heat stress in their cows. Overall, farmers considered heat stress as an issue marginally affecting milk yield and cow welfare (average score: 3.40 and 3.16, respectively), whereas effects on cow fertility and immune system were considered as less relevant (2.40 and 2.12, respectively). Environmental temperature and humidity, the productive merit of the cow, and the use of pasture were considered as main factors affecting heat stress in cows (score > 3). The improvement of drinking points and shadow areas in the pasture were considered as the main mitigating actions to alleviate cows heat stress (3.56 and 3.28, respectively), whereas the alternative option of the indoor housing of the herd for the entire summer, even in barns equipped with sprinklers and fans, was poorly rated by the Alpine farmers.
Conclusion: Global warming is supposed to increase the risk of heat stress also for dairy herds grazing on high elevation pastures, and signs of heat stress have been already detected in lactating cows grazing in the Alps. However, Alpine dairy farmers still do not consider heat stress as a relevant risk factor for their herds during summer grazing. Therefore, actions should be taken in the near future to train Alpine dairy farmers about the risks and consequences of heat stress in cows, and specific guidelines should be produced to mitigate heat stress effects also for herds grazing in the Alpine regions. As heat stress signals were mainly reported by farmers rearing Holstein cows, future research should also assess the adaptive response to the summer heat exposure of cows belonging to less producing dual-purpose or autochthonous breeds.

Grazing strategies and their relationship to traits of milk performance testing in cattle

Fuerst-Waltl B.[1], Musati M.[2], Coppa M.[2], Fuerst C.[3], Ivemeyer S.[4], Klopčič M.[5], Martin B.[2], Winckler C.[1]

[1] University of Natural Resources and Life Sciences (BOKU), Vienna (AT), [2] Université Clermont Auvergne, INRAE, Saint-Genès-Champanelle (FR), [3] ZuchtData EDV-Dienstleistungen GmbH, Vienna (AT), [4] University of Kassel, Witzenhausen (DE), [5] Slovenian Holstein Association, Domžale (SI); birgit.fuerst-waltl@boku.ac.at

Keywords: extensive pastures, young stock, dairy traits

Introduction: Transhumance or droving livestock to other areas during summer months is highly relevant for agriculture in central Europe. It enables the utilization of additional forage areas while reducing the work burden on the home farm and may thus lead to a higher profitability. Access of young stock to mountain or extensive pastures is often claimed to be beneficial, but robust evidence on animals' later career is scarce. Alpine transhumance of young stock has e.g. been shown to have positive effects on longevity (Fuerst-Waltl et al. 2019; Krogmeier et al., 2015). In this study, as a first step, traits of milk performance testing of cows that had been reared at least partially (as young stock) in extensive transhumance grazing systems, were compared with those of cows that stayed (as young stock) on home farms in Austria (AT), France (FR) and Slovenia (SI). In the extensive systems analysed, transhumance to summer alpine (AT, SI), upland (FR) or Karst pastures (SI) is typically practised.

Animals, materials and methods: Data from 20 herds (conventional low input farms, breeds Holstein and Montbéliarde) in the Massif Central Region in FR and 21 herds (5 organic, 16 conventional; breeds Brown Swiss, Fleckvieh, Holstein and crosses) in SI were partially collected on-site and combined with database records. For AT, data from the national database were provided for all organic farms breeding Fleckvieh. After restrictions for data completeness, records of 1 052 herds remained in the data set. For all countries, animals born from 2010 onwards and calving until end of 2019 were considered. After plausibility checks, 21 435, 2 353 and 1 330 first lactation records as well as 75 414, 13 515 and 11 702 test-day records were available for AT, FR and SI, respectively. For SI, the classes Karst and alpine pasture were merged for reasons of class occupancy. Alpine, Karst and upland pastures will be referred to as mountain pasture in the following. Due to the different data structure, records were analysed separately for each country by means of the SAS procedure mixed. In the models, herd*year (FR, SI) or herd (AT) was fitted as random effect, mountain pasture, age at first calving and calving year*calving month as fixed effects. For AT, herd was nested within the random effect of region, and the fixed effects alpine grazing of cow and grazing on-site (farm information) were included. For SI, the effect grazing of cows (either on-site or Karst/mountain), available as farm information, was included as fixed effect. Additionally, the fixed effect of breed was fitted for FR and SI data. For the analyses of first lactation Somatic Cell Score (SCS), test-day records were analysed applying the same models and additionally including the random effect of cow and the covariate days in milk (linear, squared). The level of significance was generally set to $\alpha = 0.05$. All main effects remained in the model independent of p-levels while interaction terms were discarded at $p>0.05$.

Results: Mostly, animals that were on a mountain pasture during the rearing period had a lower 305d milk yield. For SI, the main effect was however not significant. In AT, the interaction with grazing on farm was significant; animals that were neither grazed on mountain pasture during the rearing period nor on-site in general had significantly higher milk yields compared to all other combinations of effect levels. For SI, interaction terms with breed and cow grazing were significant. Highest milk yields were achieved by cows neither reared with access to mountain pastures nor grazed as cows; Fleckvieh cows with access to mountain pasture as young stock had higher milk yields in the first lactation. For the traits 305-day fat and protein yield results were more or less corresponding to the ones of 305-day milk yield. No significant effects of mountain pasture were however observed for fat and protein content. Overall, cows that had access to mountain pastures as young stock had lower SCS during the first lactation in all countries. However, the main effect was significant in AT only. In FR and SI, significant interactions indicated differences across breeds. In both countries, Holstein cows with access to mountain pastures as young stock had somewhat higher Least Squares Means for SCS ($p>0.05$ in both countries, however; Tukey test) than those without.

Conclusion: With the exception of SI Fleckvieh, first lactation 305-yields of cows that were partially reared on extensive alpine, upland or Karst pastures were below those that were kept on home farms only. Apart from Holstein cows in FR and SI, SCS was however lower for cows that had experienced mountain pasture during young stock rearing. Next steps include analyses of further functional traits, i.e. fat-protein-ratio and fertility traits.

The restoration of abandoned temperate forests with semi-free-range pigs: the experience of 'Food for Forest'

Nota G.[1], Berretti R.[1], Ravetto Enri S.[1], Pittarello M.[1], Barberis D.[1], Ascoli D.[1], Motta R.[1], Lombardi G.[1], Battaglini L. M.[1], Lonati M.[1]

[1] Department of Agriculture, Forest and Food Sciences (DISAFA), University of Torino (IT); ginevra.nota@unito.it

Keywords: Silvopastoral system, agroforestry, pig grazing, feeding behaviour, sustainability

Introduction: The reduction in the management of European temperate forests might adversely impact the numerous ecosystem services provided by these habitats (e.g. hydrogeological stability, biodiversity, recreational and aesthetic value, etc.). Silvicultural practices in such abandoned stands are often hindered by the abundance of shrubs in the understory, such as bramble (*Rubus* spp.), which reduces the access to the area for workers and require unprofitable clearing operations. The project 'Food For Forest' (funded by Piedmont RDP programme 2014-2020) proposes a multifunctional silvopastoral system coupling pig grazing and silvicultural treatments for the sustainable use and restoration of degraded temperate forests. With this system, pigs would facilitate silvicultural interventions through the reduction of undesirable plant species in the understory, while farmers would benefit from low-cost forages to feed animals. Moreover, this farming system ensures the provision of an environmental- and animal- friendly product for the market. Within this framework, we aimed to i) study plant species selection of semi-free-range pigs, ii) evaluate the damages to post-treatment tree resprouting by pigs and iii) assess the weight gain of animals.

Materials and methods: The study was carried out in two semi-abandoned hill stands located in Piedmont region (NW Italy) and dominated by *Quercus robur* and *Castanea sativa*. Here, a rotational grazing system with 20 Nero di Parma barrows was applied from April to December (240 days) in 2019 and 2020. Nose rings were provided for swines to avoid rooting. During the first year, swine feeding preferences were assessed through direct observations by monitoring animal behaviour at three-minute intervals during 30-sec. observations. For each observation, the plant species consumed and those present in the surroundings of the pig were recorded. We focused on the selection of aboveground green tissues, while the occasional consumption of acorns and roots was not considered. Based on these data, a Selection Index (SI) was calculated for each plant species following Manly et al. (2002). In the second year, a silvicultural renovation cut removed 36% of the wood volume in the coppice layer. The sign of grazing on buds and leaves, and the growth of 1045 resprouts belonging to seven tree species were evaluated through the growing season. Finally, live weight gains of pigs were assessed throughout the grazing period, from 10 to 18 months age.

Results: The species *Corylus avellana*, *Hedera helix*, *Robinia pseudoacacia* and *Rubus* spp. were actively selected by pigs (SI >1). Among others, the species consumed proportionally to their availability (SI =1) were *C. sativa*, *Cornus sanguinea*, *Prunus avium* and *Ulmus minor*, while the avoided ones (SI <1) were *Fraxinus ornus*, *Ligustrum vulgare* and the oaks (*Q. cerris*, *Q. pubescens* and *Q. robur*). Sprouts of *C. avellana*, *C. sativa* and *U. minor* were damaged the most, followed by *F. excelsior* and *P. avium*. Swine grazed firstly buds, while later in the season both buds and leaves were consumed. *F. ornus* and *R. pseudoacacia*, instead, had a few sprouts damaged (4% and 20%, respectively) and stump heights increased through time. The lower preference for sprouts compared to mature leaves of *R. pseudoacacia* suggests that young tissues may contain chemical compounds reducing their palatability. On average, pigs grew from 59.7 to 157.1 kg LW, reaching the maximum LW gain in June (0.77 kg/d).

Conclusion: The results showed that pigs selectively consumed the plants available in the understory and the sprouts of tree species, providing novel knowledge on pigs diet preferences. Moreover, the large consumption of bramble suggested that pigs could be a suitable tool to control this undesired species in the understory. As regards the economic sustainability, the reduced demand for feed supplements, the high value of the meat on the market, and the improved quality of the woody stands are expected to positively balance the farmers' profits. Therefore, the silvopastoral system proposed by 'Food for Forest' can be a sustainable management approach for the restoration of degraded temperate forests, allowing the enhancement of the related ecosystem services.

Cattle breed – an underestimated driver of mountain pasture management

Pauler C. M.[1], Isselstein J.[2], Bérard J.[1,3], Schneider M. K.[1]

[1] Animal Production Systems and Animal Health, Agroscope, Posieux and Zurich (CH)
[2] Department of Crop Sciences, Georg-August-University, Goettingen (D), [3]AgroVet-Strickhof, Lindau (CH);
caren.pauler@agroscope.admin.ch

Keywords: biodiversity, cattle breeds, claws, forage selection, movement behaviour, productivity

Introduction: During the last century, modern breeding speeded up changes in livestock characteristics enormously. In cattle, a wide range of breeds were formed. High-productive, specialised dairy or beef cattle differ enormously from low-productive, traditional breeds – not only in appearance and productivity, but probably also in anatomy, movement and foraging behaviour. Such differences could have far-reaching consequences for pasture vegetation, especially in mountain pasture systems where grazing livestock is a major ecological factor of vegetation composition.

Materials and methods - Substudy I: Three cattle breeds represented different levels of productivity: (i) low-productive Highland cattle, (ii) traditional, dual-purpose Original Braunvieh and (iii) high-productive Angus×Holstein crossbreed. The cattle simultaneously grazed three types of heterogenous subalpine pastures in the Swiss Alps (2026 m asl.). Individual body weight and claw base area were measured. To analyse the movement behaviour, we recorded speed, space use evenness and step frequency using GPS tracking and pedometers. We visually observed foraging behaviour of each cow by recording selected plants, and calculated the selectivity for different plant species and traits (e.g., forage quality, defence mechanisms). Allometric relationships among anatomy, foraging and movement parameters were analysed by standardized major axes. **Substudy II:** To explore long-term breed effects on pasture vegetation, we conducted an observational vegetation study in Switzerland and Germany. At 25 sites, pastures grazed by Highland cattle for at least 5 years, were compared to similar, adjacent pastures of more productive cattle. We recorded the percentage cover of all plant species and assigned them to indicator values of trampling and grazing tolerance.

Results: There were consistent differences among breeds with respect to almost all factors analysed. Especially Highland cattle differed from the two more productive breeds significantly, while there was only little divergence between Original Braunvieh and Angus×Holstein cattle. Highland cattle were significantly lighter than the other two breeds. On average, Highland cattle weight 358 kg, Original Braunvieh 582 kg and Angus×Holstein 679 kg. Claw base was also smaller in Highland cattle, but it was relatively large compared to the weight: On each square centimetre claw base of a Highland cow burdened about one third less body weight than of an Angus×Holstein cow. The low body weight on relatively large claws of Highland cattle reduces physical pressure. Accordingly, we found significantly less trampling-adapted plant species on Highland cattle pastures. GPS and pedometers indicated that Highland cattle moved least, but used the space most evenly. The more productive a breed was, the higher the forage selectivity and step frequency. Highland cattle foraged most evenly and thereby chose the diet of lowest quality. Since they were least choosy while foraging, they needed to walk shortest distances, as they just fed on what was in close proximity to their mouth. Thereby, they additionally reduce trampling pressure. Original Braunvieh and Angus×Holstein foraged more broad-leafed grasses and legumes than Highland cattle, while nutrient-poor species, woody plants or plants with physical defence mechanisms (e.g., thistles) were consumed by Highland cattle much more frequently. Accordingly, these plants were significantly less abundant on pastures grazed by Highland cattle for at least 5 years. On nutrient-poor subalpine pastures, cattle commonly lose weight. Although Highland cattle chose a diet of lower forage quality, they showed an average daily weight gain of 0.08 kg, whereas the other two breeds lost 0.3 kg (Original Braunvieh) and 0.6 kg (Angus×Holstein) per day. Highland cattle compensated the lower energy intake by their unhurried movement behaviour, their warming fur and likely by a more efficient food conversion of the fibre-rich diet.

Conclusion: Pastures grazed by Highland cattle were significantly more species-rich than comparable pastures of productive cattle and these differences increased with the duration a pasture was grazed by the breeds. This finding is well explained by a lower trampling pressure and the less selective foraging behaviour of Highland cattle, which prevent highly competitive species from overgrowing more susceptible plants. Hence, low-productive breeds such as Highland cattle are able to cope with the rough environmental conditions of alpine pastures and make efficient use of them. Thereby, they can help to conserve the species richness of these vulnerable habitats.

Beef livestock system in a silvopastoral area of Sardinia

Acciaro M.[1], *Manca C.*[1], *Marrosu M.*[1], *Sitzia M.*[1]

[1]*Agenzia per la Ricerca in Agricoltura, Agris Sardegna, Sassari, Italy; macciaro@agrisricerca.it*

Keywords: grass-beef, grain-beef, natural pasture, feeding costs

Introduction: The marked decrease in the number of livestock farms in Italian and Mediterranean mountains, due to the lack of remuneration of agricultural and livestock production activities, with a consequent uncontrolled woody species encroachment, resulted in negative effects on the ecosystem services. The exploitation of such areas in Sardinia with Sarda cattle breed may prevent further encroachment of pastures and allow the production of grass-fed meat, with a view to increase farmer revenue. In this work, part of a long-term research project (iGRAL - Innovative beef cattle Grazing systems for the Restoration of Abandoned Lands in the Alpine and Mediterranean mountains), ordinary finishing system of calves, with calves finished in a conventional specialized fattening centre (grain-beef, OG) was compared with an innovative grass-fed system involving the finishing of calves at pasture (IG).

Materials and methods: The trial was carried out at the Macomer experimental farm of Agris Sardegna (39°N, 9°E, 670 m a.s.l.), from January 2019 to June 2020. Characterized by a Mediterranean climate, with a dry summer, cold winter and average annual rainfall of 568 mm., the area is encroached mainly by downy oaks (*Quercus pubescens* s.l.), and shrubs of *Pruno-Rubion* and *Cytisetea scopario-striati*. Secondary grasslands are represented by *Poetea bulbosae* (habitat 6220*), *Molinio-Arrhenatheretea* and *Stellarietea mediae*. Twenty mature Sarda cows with their calves (13/11/2018±5, means±SE, calving date) were split into two groups: OG (8 cows) and IG (12 cows). The area was continuously grazed with a stocking density of 174 kg Body Weight (BW) of cow/ha, according to traditional suckler-cow system. OG calves were weaned at 211±7 days old (20/6/2019) and 254±7 kg of BW and fattened into a specialized fattening centre until slaughter. IG calves were weaned at 186±7 days old (13/5/2019) and 210±7 kg of BW, and finished at pasture, with feeding supplement according to the herbage availability. IG was weaned earlier than OG to exploit for a longer time the spring vegetative growth of the pastures. BW of calves was detected monthly. The average body-weight daily gain (ADG) was then calculated considering separately the suckling and the fattening period (from weaning to slaughter (on 28/01/2020 for OG animals, on 23/03/2020 for IG females, and on 8/5/2020 for IG males, when their live weight reached 522 kg, corresponding to the bodyweight at slaughter of OG males). Supplementary feed supplied to IG calves was measured daily as well as the amount of feed given to OG calves in the fattening centre. The feeding cost, expressed as euro/kg of ADG, was also calculated.

Results: ADG of calves is shown in Table 1. The treatment and the sex of calves did not affect the ADG in suckling period (1.11±0.03 kg/day, lsmeans±SE and 1.03±0.02 kg/day, OG and IG respectively; 1.10±0.03 kg/day and 1.04±0.03 kg/day, males and females, respectively), despite the early weaning led to a lower ADG of IG than OG (0.94 and 0.60 kg/day in OG and IG respectively, P=0.03), during the period when OG calves were still suckled by their dams (from 13/05 to 20/06/2019). After weaning, ADG was affected by the finishing system, (0.90±0.04 and 0.69±0.03 kg/day, OG and IG calves respectively, P=0.001) and by sex (0.93±0.03 and 0.66±0.03 kg/day, males and females, respectively, P<0.001). The feeding costs did not differ between treatments (2.26±0.08 vs 1.95±0.10 euro/kg ADG, IG and OG respectively, P=0.06), despite the numerically highest cost of IG females (Table 1) likely due to their lowest ADG.

Table 1. Average Daily Gain (ADG) of IG and OG calves during the suckling and fattening period and feeding cost (euro/kg ADG) during finishing period (lsmeans±SE)

	ADG suckling period	ADG fattening period	Feeding cost (euro/kg of ADG)
Male calves OG	1.14±0.03	1.04±0.04a	1.80±0.14
Male calves IG	1.06±0.03	0.82±0.03b	1.73±0.09
Female calves OG	1.08±0.04	0.76±0.04b	2.09±0.12
Female calves IG	0.99±0.03	0.55±0.04c	2.79±0.12

Means in the same column with no letters or with a common letter after them are not significantly different (P>0.05);

Conclusion: The results show that Mediterranean silvopastoral areas can support the production of grass-beef and the livestock activities and, thanks to the human presence, the conservation of the ecosystem services that these areas provide.

Environmental sustainability of summer grazing or no summer grazing farming systems in a Lombardy alpine valley: two case studies

Gislon G., Chiaravalli M., Colombini S., Bava L.

Università degli Studi di Milano, Dipartimento di Scienze Agrarie e Ambientali, Milano (Italy); luciana.bava@unimi.it

Keywords: farming system, milk, summer grazing, LCA

Introduction: Environmental sustainability of dairy farming is becoming crucial in some Alpine areas where a process of intensification is leading to a significant increase of animal per farms and use of external inputs. As suggest by Berton et al. (2020), great variability in farming systems can be identified in the Alps, where low-input and low-productivity farms coexist with high-input and high productivity farms. Recently some studies analyzed the environmental impact of different mountain farming systems through a Life Cycle Assessment approach (Jan et al., 2012; Penati et al., 2013; Salvador et al., 2016). About livestock sector sustainability, it is also important to consider the ability of the animal to turn feed resources into edible animal food. The aim of the study is to compare the sustainability of two dairy farming systems, whether or not characterized by summer grazing, as environmental impact of milk production. Moreover, the potential competition for food between humans and animals was considered.

Materials and methods: The present study involved 2 dairy farms located in the Italian Alps (Sondrio province); one transferred the whole herd to high altitude pastures for 3 months in summer (summer grazing SG) while the other maintained the herd in the valley barn all over the year (noSG). The evaluation of environmental impact was performed using the LCA procedures reported by Gislon et al. (2020). The IDF (2010) allocation method and functional unit (1 kg of fat and protein corrected milk, FCPM) were chosen. According to Wilkinson (2011) and Berton et al. (2020), the potentially human-edible share of the rations was estimated as ECR (conversion of feed MJ into milk MJ) and HeCR (conversion of potentially human edible MJ in feed into milk MJ).

Results: Lower dimensions characterized the SG farm as number of lactating cows (20) and land (13 ha in lowland and 30 ha in highland at 1800 m above sea level) compared with the noSG one: 245 lactating cows and 122 ha. Individual milk production was 26.2 and 20.0 kg FPCM/d during the no grazing and grazing period, respectively, for SG, while it was 25.4 kg FPCM/d for noSG. Feed rations were based on hay and concentrate, and fresh grass and concentrate in SG, while in the noSG the ration also included corn silage and grass silage forages. The main results about the potentially human-edible share of the rations are shown in table 1. The summer ration was not as efficient as the other rations in convert feed energy into milk energy (ECR), mainly due to the low milk production during the grazing period, while it was well able to convert human-edible energy (HeCR) into milk. There were differences for the HeCR between the 2 farms in the lowland: the more intensive farm (noSG) had a lower value (0.90) than the SG (1.71). The difference is explained by a higher use of non-human edible feed (68.5% of total DM) in no SG farm than in SG farm in the lowland (45% of total DM). Particularly, the ration of SG farm in the lowland (hay as forage basis) was characterized by a higher inclusion of energy ingredients such as cornmeal than the noSG ration based on corn silage.

Table 1. Potentially human-edible share of the ration

		SG		noSG
		lowland	highland	lowland
ECR	MJ feed/MJ milk	3.31	5.36	4.15
HeCR	MJ feed/MJ milk	1.71	0.94	0.90

Results of LCA showed a slightly lower environmental impact for milk production (as kg of FPCM) of SG compared to noSG: 1.30 vs. 1.36 kg CO_2 eq for climate change; 0.017 vs. 0.037 molc H+ eq for acidification, but a higher impact for freshwater eutrophication (0.084 vs. 0.041 g P eq) and land use (21.59 vs. 13 kg C deficit).

Conclusion: The comparison among traditional dairy farming systems with the use of summer grazing vs. a more intensive system highlights that the low milk production of the SG system could penalize some environmental impact categories and the gross energy conversion ratio. On the other hand, the low use of input as concentrate feed in noSG system reduces climate change per unit of milk and potentially human-edible gross energy conversion ratio.

Do beef cows reared on mountain pastures of central Spain need to be supplemented?

Lobón S.[1], Joy M.[1], Casasús I.[1], Casado P.[2], Torres C.[2], Blanco M.[1], Sanz A.[1]

[1]Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA) - IA2 (CITA-Universidad de Zaragoza), Montañana 930, 50059 Zaragoza, Spain
[2]General de Piensos de Soria (GEPISA), Ctra. Logroño, 42162 Garray, Soria, Spain; slobon@cita-aragon.es

Keywords: mountain grazing, natural resources, supplementation, suckler cows

Introduction: Beef cows in mountain areas are managed during long periods on natural pastures, where their performance is affected by seasonal variations in forage avalability and/or quality. The aims of this study were: I) to evaluate the quality of available pastures throughout the year in an extensive cow farm, and II) to estimate the timing, amount and type of supplement required to maintain permanently cows on these pastures.
Materials and methods: The study was carried out in a mountain farm located in Campisábalos (central Spain, 41º 15´N, 3º8´W; 1350 m a.s.l.). The suckler cows (n=128) grazed permanently on natural grasslands, meadows, and shrub and forest pastures (total of 2200 ha). Samples of the pastures where cows were grazing at the time of sampling were collected every 1.5 months, from May 2018 to May 2019. On each date, 3 samples per ha were obtained to determine the contents of dry matter (DM), crude protein (CP), neutral detergent fibre, acid detergent fibre, acid detergent lignin and ash. A free on-line software (www.remugants.es, by REMUGANTS "Ramon Trias") based on the INRA feeding system for ruminants was used to a) calculate the forage nutritive value, b) determine the energy and protein requirements of cows in different physiological states (non-pregnant, late pregnancy, initial lactation, mid-lactation), and c) evaluate if diets based on *ad libitum* intake of the sampled pastures were able to meet cow requirements. The quantity of forage that cows should eat was calculated according to their physiological state, while maintaining a body condition score of 2.5 at calving and a daily milk yield of 10 kg/d over 6 months of lactation. Moreover, forage intake was calculated taking into account the maximum intake capacity of the cow and the fill value of the forage. When *ad libitum* forage intake did not meet requirements, three types of concentrate differing in the CP content (with 18, 15 or 12%) were tested as supplements.
Results: In spring, forage quality (13.9 and 11.5% CP, and 5.7 and 5.5 MJ NEl/kg DM, in May and June, respectively) was enough to maintain the body condition score of cows, then no supplementation was advisable (Table 1). The quality of forage decreased thereafter, down to 7.3% CP, and 4.4 MJ NEl/kg DM in August, and 5.4% CP, and 4 MJ NEl/kg DM in October; only lactating cows needed a high-protein supplement on these dates. However, the low CP content could have decreased the intake, therefore the supplementation of non-lactating cows should be revised. In December, forage quality improved (13.7% CP, and 6.7 MJ NEl/kg DM) and no supplement was needed, although forage availability was minimum (not determined), which may compromise a sufficient forage intake. In February and March forage quality and availability were very low, due to persistent snowfall and the late start of the growth season. All the cows needed supplementation, ranging between 1.5 and 4.5 kg. Finally, in May the quality (12.7% CP, and 5.6 MJ NEl/kg DM) was enough to maintain the herd without supplementation.

Table 1. Amount (kg DM) and type of concentrate needed depending on the physiological state.

Cow	Non-pregnant	Late pregnancy	Initial lactation	Mid-lactation
May 2018	NO	NO	NO	NO
June 2018	NO	NO	NO	NO
August 2018*	NO	NO	1.5 kg (18% CP)	1 kg (18% CP)
October 2018*	NO	NO	2.5 kg (18% CP)	2 kg(18% CP)
December 2018*	NO	NO	NO	NO
February 2019	1.5 kg (15% CP)	2 kg (15% CP)	4.5 kg (15% CP)	4.5 kg (15% CP)
March 2019	3 kg (15% CP)	4 kg (15% CP)	6.5 kg (15% CP)	6.5 (15% CP)
May 2019	NO	NO	NO	NO

*Cows should be supplemented due to the low CP content or the limited quantity of forage available.

Conclusion: The quality of forage was enough to maintain the herd without supplement during some months. These data showed the interest of managing the herd in batches according to their physiological state, allowing the farmer to reduce feed costs.
Supported by European Regional Development Funds, PDR Castilla y León 2014-2020 (1433/C01, 1460/C01).

Nitrogen farm balance and efficiency in mountain dairy farms

Tamburini A.[1], *Gislon G.*[1], *Bava L.*[1], *Zucali M.*[1], *Sandrucci A.*[1]

[1] *Dipartimento di Scienze Agrarie e Ambientali, Università degli Studi di Milano (IT*);
alberto.tamburini@unimi.it

Keywords: Farm Nitrogen balance, Dairy Efficiency, dairy cows, sustainability

Introduction: In the recent decades the evolution of dairy farming in the mountain areas led to the progressive abandonment of livestock activities, or, conversely, to an increase in animal density, in the attempt to maintain profitability. Intensification implied an increase of purchased feed (fodder and concentrates), not always from neighbouring mountain areas (Penati et al., 2011). The purchase of feed for livestock can be considered economically advantageous, compared to the cost of production in the mountain and the management of summer pastures (Sturaro et al., 2013), but certainly involves an increase in the surplus of nutrients (N and P) at the farm level (Gamborg and Sandøe, 2005). The aim of the study was to investigate the Nitrogen Balance (NB) at dairy farm level, in 2 Lombardy mountain areas, in relation to feed self-sufficiency and Dairy Efficiency (DE).

Materials and methods: The survey was carried out in 2 groups of dairy cattle farms for a total of 82 farms from the province of Sondrio (Italy), 38 from Valcamonica and 44 from Valtellina-Valchiavenna. Data were collected through questionnaires, provided with direct interviews to farmers. Data on the average milk production and quality were acquired from the dairies, or directly from the farm data. Composition of animal rations were collected as well as purchased (feed, animal, fertilisers), crop productions and pasture characteristics. Farm feed self-sufficiency was calculated as difference between the feed dry matter required by all animals and the purchased feed dry matter. Milk production was standardized (Fat and Protein Corrected Milk, FPCM). DE was calculated as FPCM/dry matter intake ratio, on individual dairy cow basis. Nitrogen Balance (NB kg/ha) at farm level was estimated as difference between N inputs (feed, fertilisers, bedding, animals purchased, deposition and fixation on the fields) and N outputs (delivered milk, feed/crops, slurry/manure, delivered or dead animals).

Results: The farms studied were representative of the mountain dairy farming in Lombardy, as small cultivated land area (18.2 ± 11.6 ha, of which 81.9% as permanent grass), small size in terms of livestock units (53.6 ± 39.9 LU) and lactating dairy cows (35.8 ± 26.0). The animal density per ha of cultivated area was high (3.07 ± 1.69 LU/ha) and only 48.8% of farms used high altitude pastures during the summer, both for dairy cows and heifers, while 12.2% of farms did not use summer pastures at all. Total farm feed self-sufficiency was low (49.7 ± 19.6% of the total DM intake for all farmed animals. Individual milk yield was low (17.9 ± 5.58 kg FPCM/d) and DE was very low (0.92 ± 0.22 kg FPCM/kg DM intake). Nitrogen Balance was unsatisfactory (206 ± 138 kg N/ha per year) and showed a high variability, with 117 kg N/ha for Q1 (25% of farms) and 263 kg N/ha for Q3 (75% of farms). From purchased feed, 82.3% of total N inputs was derived, while 89.0% of total N output was due to delivered milk. From a Factor Analysis, 3 significant (eigenvalues >1) factors emerged. The first one (39.4% of the total variance) including stocking rate (LU/ha), farm size (No. LU), N in purchased feed, N in delivered sand N balance as positive effect, and feed self-sufficiency % on total DM intake as negative effect was labelled "stocking rate and N balance". The second factor (24.6% of the total variance) was labelled "Dairy Efficiency and crop land size" and included DE, individual milk production and crop land size in ha, as positive effect). The third factor (13.6% of the total variance) was labelled "Forage % and farm N efficiency" (involving forage % of total DM intake of lactating cows and farm N efficiency, determined as N output/N input, as positive effects). The consequent Principal Component Analysis showed a high positive correlation for DE, N efficiency and farm size (total crop land area and total LU), and a negative correlation for N balance, N from purchased feed, stocking density and forage % of lactating cows DM intake. Feed self-sufficiency showed a negative correlation with other parameters, particularly with DE and stocking density.

Conclusion: The study showed some problems for the dairy farming systems in the considered Lombardy mountain area, in terms of low feed self-sufficiency, high stocking density and high farm N balance. The increase of DE and N efficiency can lead to the decrease of self-sufficiency and use of forage in the diets for cows. Therefore, a lot of effort must be made to improve forage quality in the mountain areas (production of haylage instead of hay, more attention to the stage of maturity of forage crops and permanent grasses at harvest). Summer pasture can be a solution to improve the total forage availability in farms, but it seems to be inefficient in terms of economic efficiency and DE. Low stocking density allows low farm N balance, but it seems to be achieved easier with a high total LU in a large crop land area than with a low LU in smaller farms, on basis of the low profitability.

Systems biology approach to study high-altitude genetic adaptation in Bosnian mountain horse

Zorc M.[1], Ferme T.[1], Horvat, T.[1], Mesarič M.[2], Dovč P.[1]

[1]University of Ljubljana, Biotechnical Faculty, Dept. of Animal Science, Ljubljana, Slovenia
[2]University of Ljubljana, Veterinary Faculty, Clinic for Reproduction and Large Animals, Ljubljana, Slovenia;

Keywords: Bosnian mountain horse, conservation measures, epigenetics, high-altitude adaptation, hypoxia, miR218

Introduction: The Bosnian mountain horse is an indigenous horse breed originating from Bosnia and Herzegovina. Its original habitat is the Dinaric mountain area, characterized by a rough climate and high-altitude. The breed represents an ancient horse type originating from crosses between Tarpan and Mongolian wild horse breeds and has been valued for its working ability since the Middle Ages. In spite of several attempts to introduce the Arabic blood to this breed, the local breeders resisted this pressure and preserved this genetic resource through centuries. Systematic selective breeding is performed since 1900. The most important breeding centre has been Bosnian Stud farm Borike at 950 m above the see-level. The location of the Borike stud and the use of this breed in mountain regions favoured adaptation of the breed to a harsh mountain environment. In general, species living at high altitude develop physiological and morphological traits which allow adaptation to this special environment. The values for haematological parameters in the Bosnian mountain horse are in the upper range of normal values reported as reference values for the domestic horse. This supports the observation that ascent to high altitude is associated with an expansion of red cell mass. Genomic studies revealed genomic regions encompassing the *STXBP4*, *COX11*, *HLF*, *MMD* and *CALCOCO2* genes on chromosome 11 and the *RALB* and *INHBB* genes on chromosome 18 that appear to be under selection and are associated with adaptation to high altitude in the Bosnian mountain horse as well as in other horse breeds. In this study, we used publicly available data from the previous study (Grilz-Seger et al., 2019) for the identification of additional loci associated with adaptation to high altitude in Bosnian mountain horse.
Materials and methods: Runs of homozygosity (ROH) islands, stretches of homozygous sequences in the genomes of a large proportion of the Bosnian mountain horse population were identified in the previous study. Within ROH islands spanning chromosomes 11 and 18, genes previously associated with high-altitude, were identified and used in bioinformatics analysis. Lists of genes provide valuable information, but they alone cannot explain the complex mechanisms they are involved in. Therefore, we performed the pathway enrichment analysis using g:Profiler and DAVID tools to identify biological pathways that are enriched in a gene list more than would be expected by chance. Moreover, we performed microRNA target enrichment analysis using the MIENTURNET tool and TargetScan database to identify additional, non-coding genes that play role in adaptation to high elevation.
Results: Functional analysis revealed enrichment of positive regulation of macroautophagy and cellular response to starvation. MicroRNA target enrichment analysis discovered that *miR148a-3p/miR148b-3p/miR152-3p* and *miR218-5p* regulate three candidate genes (*INHBB, MMD* and *HLF*). It has been shown that *miR218* is differentially expressed in the yak and bovine transcriptome. Its repression increases the abundance and activity of several receptor tyrosine kinase (RTK) effectors and promotes activation of hypoxia-inducible factor (HIF), which orchestrates the transcriptional response to hypoxia, a condition in which tissues of the body are starved of oxygen.
Conclusion: We identified candidate genomic regions in Bosnian mountain horse involved in the regulation of expression level of genes related to biological pathways with a key role in high-altitude adaptation (macroautophagy and cellular response to starvation). Bosnian mountain horse is already known for its adaptability to the harsh mountain environment and can outcompete other breeds which are not adapted to such environment. Studying the genetic background of high-altitude adaptive mechanisms can contribute to the improvement of genomic characterisation of livestock breeds and plays an important role in planning conservation measures and management of local animal genetic resources.

Effect of the sainfoin preservation on the secondary compounds and antioxidant activity

Joy M., Rufino-Moya P. J., Bertolín J. R., Lobón S., Blanco M.

Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA) - IA2 (CITA-Universidad de Zaragoza), Montañana 930, 50059 Zaragoza, Spain; slobon@cita-aragon.es

Keywords: polyphenols, carotenoids, tocopherols, *Onobrychis viciifolia*

Introduction: The polyphenols, carotenoids and tocopherols are secondary compounds in forages. These compounds are abundant in fresh forages and increase the antioxidant (AO) activity (Debier and Larondelle, 2005), being able to improve the milk and meat quality (Kumar, 2015). Fresh sainfoin (*Onobrychis viciifolia*) is a perennial legume with high nutritional value and medium to high secondary compounds content (Rufino-Moya et al., 2019). However, it is needed to preserve the sainfoin because two thirds of its annual production is obtained with the first cut of spring. The aim of this study was to evaluate how the preservation method affected the contents of these secondary compounds and AO activity.

Materials and methods: Fifteen samples of sainfoin were collected at the late bloom stage and divided into samples for fresh forage (n=5), hay (n=5) and silage (n=5) (for details see Rufino-Moya et al., 2019). The samples for hay were naturally sun-dried, whereas the samples destined to make silage were wilted one day, chopped (3-5 cm) and vacuum-ensiled in plastic bags for 82 days. The total polyphenols were extracted (Makkar, 2000) and quantified (Julkunen-Titto, 1985). The carotenoids and tocopherols extracted (Fu et al., 2011) were determined by chromatography (Chauveau-Duriot et al., 2010). The AO activity (Roncero-Ramos et al (2017) was assessed through the free radical scavenging activity (DPPH and ABTS assays) and the ferric reducing antioxidant power (FRAP). Data were analysed using SAS v 9.1. with a general linear model (5 replicates each method) considering the method of preservation as fixed effect. The LSMeans and their associated standard errors and differences between means were obtained using the Tukey correction.

Results: The method of preservation affected all the parameters ($P<0.001$) (Table 1). Fresh sainfoin and hay had greater polyphenol content than the silage ($P<0.001$). Fresh sainfoin had highest contents of xanthophylls and all-E-β-carotene. The hay had the greatest γ-tocopherol, whereas the silage had the greatest 13z- and 9z-β-carotenes. Regarding the AO activity, the silage had the lowest values in the three parameters ($P<0.001$). The hay had greater ABST, similar DPPH and lower FRAP than the fresh sainfoin.

Table 1. Effect of the preservation method on secondary compounds and antioxidant activity in sainfoin

	Fresh	Hay	Silage	s.e.	P-value
Polyphenols, eq-g tannic acid/kg DM	44.6a	47.1a	34.1b	5.6	0.0001
Neoxanthin, μg/g DM	35.1a	14.9b	N.D.	0.23	0.0001
Violaxanthin, μg/g DM	12.5a	6.4b	N.D.	0.19	0.0001
Zeaxanthin, μg/g DM	17.9a	11.2b	20.7a	0.28	0.0006
Lutein, μg/g DM	164a	103b	66c	1.3	0.0001
13 z-β-carotene, μg/g DM	4.87b	1.45c	11.9a	0.08	0.0001
9 z-β-carotene, μg/g DM	11.6b	4.4c	14.0a	0.1	0.0001
All-E-β-carotene, μg/g DM	101a	41.3c	52.6b	0.7	0.0001
α-tocopherol, μg/g DM	123a	61b	119a	1	0.0001
γ-tocopherol, μg/g DM	8.0c	11.4a	9.6b	0.1	0.0002
ABTS, eq-μmol trolox /g DM	311b	336a	247c	3	0.0001
DPPH, eq-μmol trolox /g DM	264a	264a	140b	2	0.0001
FRAP, eq-μmol trolox /g DM	282a	290b	189c	3	0.0001

Within a parameter, means with different letter differ at $P<0.05$.

Conclusion: the preservation method greatly affected the contents of all the parameters. Further studies are required to assess the effects of all these changes on the deposition in the tissues of the animals and evaluate the impact on the quality of the final product.

Session 2: Conflicting priorities in mountain areas

Take home messages

from oral and poster presentations

Human-carnivore conflict in the north-eastern Italian pre-Alps: a preliminary assessment *Franchini M., Strepparava A., Lora I., Ferraro E., Frangini L., Filacorda S.*
In Italy, the legal protection of grey wolves (Canis lupus) increased conflicts with livestock activities. The results presented in a study conducted in the Asiago Highlands highlights the existence of a wolf-livestock conflict requesting for the attention of researchers and local managers to promote both species conservation and coexistence in the long-term.

Electric collar prototype for sheep to deter wolves *Jordan D., Siard N., Aljančič U., Pečar B., Vrtačnik D., van Liere D.*
A new approach to sheep protection is presented along with a detailed description of the patented prototype of sheep electric collar. The ergonomic functionality of the collar has been tested and confirmed. In order to consider the proposed approach as a protection measure, a test of collar effectiveness should be performed in the field. If a drop in annual wolf attacks and sheep killed per attack is confirmed, this collar has a significant added value to protect herds in areas where current methods cannot be applied (e.g. alpine pastures). Its value in combination with existing methods can also be considered.

Characteristics and risk factors of predation by large carnivores on domestic herbivores in Valle Camonica (Italy) *Bonettini A., Tavelli P., Eterovich A., Baglioni S., Mirra G., Lo Russo F., Mattiello S.*
Predation by large carnivores seems to be an increasing issue in Valle Camonica, and certainly deserves attention. The knowledge of the distribution of wolves and bears and the identification of risk factors are essential to mitigate the conflict. To provide public bodies with a clear and realistic vision of predatory dynamics, it is essential to encourage farmers to correctly report predation events and signs of presence of the predators. Finally, farmers seem to be averse to change the way they manage their herds, and are not prone to adopt prevention methods. The promotion of campaigns to disseminate good farming practices and the use of preventive measures plays therefore an essential role for mitigating the conflict.

Attitudes of local and general populations towards agriculture, the environment and economic development in mountain areas

Muñoz-Ulecia E., Bernués A., Ondé D., Sturaro E., Martín-Collado D.

We analysed the attitudinal dimensions that build people views towards agriculture, the environment and economic development in the Spanish Pyrenees and Italian Alps. We found 4 factors representing social constructs that showed differences between countries and social groups.

Summer mountain grazing has a long tradition in the Alpine region

Dovč P., Ashja A., Klopčič M., Zorc M.

Summer grazing in mountain areas has a long history, and in the past represented an opportunity to expand the area of land used for agriculture. In addition to this objective, the eco-service and the conservation of genetic resources are gaining in importance as a result of this activity.

How can satellite technologies prevent livestock predation and mitigate excessive damage from large carnivores?

Frangini L., Franchini M., Filacorda S.

We want to present some preliminary data regarding the use of GPS collars as tool for human-carnivore conflict mitigation. Our data on Brown bear showed that satellite technologies may be adequate in reducing livestock killing, and we want to provide further insights on how these tools can be used.

Red deer (*Cervus elaphus*) grazing on permanent grasslands in Triglav National Park

Lukač B., Vidrih M., Bertoncelj I.

Losses established in our experiment are considerable and have a big influence on the forage production and available feed for the winter animal rearing at both farms. The extent of damage varies considerably between years probably due to weather conditions within growing season and availability of food for wild ungulates in the surrounding forest and at higher altitudes.

Challenges of integrating large carnivores into modern mountain pastoral systems: can they become symbols for new alliances rather than symbols of conflict?

Linell J.[1]

[1] *The Norwegian Institute for Nature Research (NINA), Trondheim, Norway; john.linnell@nina.no*

Key note summary:
Agri-environmental policies in European mountains are failing to address ongoing landscape change.

The rural mountain areas of Europe are currently facing a huge number of social, economic and environmental changes. Among these changes are the return of large carnivores to many areas of western and northern Europe from which they had been exterminated, and changes in the way they are managed in many areas of Southern and Eastern Europe with a continuity of presence. Two decades of research have revealed considerable insights into the complexity of the human-wildlife conflicts that result from these changes. This talk will summarise our current understanding of the economic and social aspects of these conflicts, as well as the potential options, and limitations, for technical interventions to address different aspects of these conflicts. The talk will wrap-up with a discussion of the largely underutilized potential for forging an alliance between pastoralists and environmentalists which has the potential to collectively address some of the real challenges that threaten the long-term viability of rural communities and mountain agriculture, instead of wasting energy fighting over symbolic scapegoats.

Human-carnivore conflict in the north-eastern Italian pre-Alps: a preliminary assessment

Franchini M.[1], Strepparava A.[1], Lora I.[2], Ferraro E.[3], Frangini L.[1], Filacorda S.[1]*

[1]Department of Agri-Food, Environmental and Animal Sciences, 33100 Udine (UD), Italy
[2]Department of Medicine, Production and Animal Health, 35020 Legnaro (PD), Italy
[3]Biologist Independent Researcher, Italy; marcello.franchini@uniud.it

Keywords: *Canis lupus*, coexistence, farmers perception, livestock predation, wolf.

Introduction: Conflicts between carnivores and livestock activities represent one of the main causes which have led to the decline of several carnivore species around the globe. In Italy, the legal protection of grey wolves (*Canis lupus*) (occurred in 1971) besides with the ecological restoration of mountainous territories (i.e., abandonment of rural areas and return of wild preys) promoted the recovery of the species in most of its former range. Extensive grazing practices in mountainous areas represent an important part of the cultural heritage and provide important ecosystem services (e.g., food, carbon recycling, habitat and biodiversity conservation). However, the recent return of the wolf in Alpine and pre-Alpine territories have led to an increased number of attacks towards livestock species, thus reducing the degree of tolerance towards this predator. The purposes of this preliminary study were (*i*) to assess the degree of conflict between wolves and extensive husbandry practices in the north-eastern Italian pre-Alps through the estimation of the minimal number of wolves inhabiting the Asiago highlands and the intensity of predation events towards livestock species, and (*ii*) to assess farmers perception about wolf presence.

Materials and methods: The study was carried out in the Asiago highlands (Veneto Region, north-eastern Italian pre-Alps) during 2019. Estimation of the minimum number of wolves living within the area was obtained using non-invasive monitoring methods (i.e., linear transects, snow-tracking, camera-trapping). Data related to predation events towards domestic species were obtained using information collected during censuses performed by the Provincial Police, Wildlife Technicians and University Researchers from 2017 to 2019. At last, information regarding farmers perception towards wolf presence was obtained using a telematic anonymous questionnaire that was sent to 40 farmers who have been renting a public Alpine pasture during the last six years, at the very least.

Results: Data collected using non-invasive monitoring methods during 2019 allowed us to confirm the presence of at least two wolf packs in the Asiago highlands occupying the northern (min = 12 ind.) and southern territory (min = 7 ind.), respectively. Predation events varied among years (n = 14 in 2017; n = 75 in 2018; n = 54 in 2019) and an almost significant increase (R^2 = 0.12, p = 0.05) was recorded. Nevertheless, a decrease of about 35% (n = 26) of the attacks was recorded in 2019. A significant correlation (r = 0.85, $p < 0.01$) was found between the number of predation events and the overall number of killed individuals per species. The highest number of predations occurred to the detriment of cattle (n = 84, 60.00%), followed by sheep and goats (n = 39, 27.86%) and horses (n = 20, 14.29%). In terms of killed specimens, ovicaprids represented the most predated species (n = 191, 64.31%, 4.90 ind./attack), followed by cattle (n = 86, 28.96%, 1.02 ind./attack) and horses (n = 20, 6.73%, 1.00 ind./attack). As far farmers perception is concerned, 20 responded to the questionnaire and, among these, 65% (n = 13) declared to have suffered predation events from 2017 to 2019. 90% (n = 18) stated that the workload increased within such period, while 65% (n = 13) declared that the use of fences for animals' containment increased as well. However, 90% (n = 18) stated that mitigation measures used were neither sustainable nor effective in reducing the attacks. Furthermore, 80% (n = 16) noticed a remarkable change in livestock behaviour in terms, for instance, of increased vigilance and avoidance of dense canopy-covered areas.

Conclusion: The results presented in this study highlights the existence of a wolf-livestock conflict in the Asiago highlands. In this sense, the synergistic participation of local authorities and research institutes should be further implemented to elaborate novel and effective mitigation measures aimed at reducing the number of attacks and promoting, hence, the maintenance of the traditional livestock practices as well as the conservation of an apex predator within such ecological context.

Electric collar prototype for sheep to deter wolves

Jordan D.[1, 3], Siard N.[1], Aljančič U.[2], Pečar B.[2], Vrtačnik D.[2], van Liere D.[3]

[1] University of Ljubljana, Biotechnical Faculty, Department of Animal Science (SI), [2] University of Ljubljana, Faculty of Electrical Engineering (SI), [3] Institute for Coexistence with Wildlife (NL); dusanka.jordan@bf.uni-lj.si;

Keywords: sheep, wolf predation, protection measures, learning

Introduction: Sheep are the most common prey species of wolves among farm animals. On pastures, they are usually protected by mobile or permanent electric fences, physical fences, guarding dogs and night enclosures. Sheep farmers often combine these measures. However, practice shows that these methods do not provide sufficient protection. Electric fences may even work counterproductive by facilitating surplus killing of farm animals that cannot flee (e.g. van Liere et al., 2013). In addition, some farmers may experience a disproportionate high number of attacks and losses. This suggests that local wolves are learning a problematic habit. As reported by sheep farmers, current measures may also increase workload, injure wild and domestic animals and, in the case of night enclosures, reduce grazing time (e.g. Gerželj et al., 2019). Shooting wolves to protect sheep may also be ineffective or counterproductive (e.g. Treves et al., 2016). Therefore, new methods of protection are needed. The aim of our research was to apply learning principles to alter wolves' choice of sheep as prey. Because attacking wolves target the sheep's neck (e.g. Kluth et al. 2019), the experience of the attack should be altered. Therefore, we developed a sheep collar that uses an electric pulse as negative reinforcement. When biting the sheep's neck, the wolf receives a painful electric shock in the mouth. Thus, a painful experience is immediately linked to the act of killing sheep. In this way, the wolf learns that killing sheep involves pain, stops killing sheep, and switches to alternative prey that is safer. This learning leads to less problematic behaviour in wolves and reduces the likelihood of sheep being killed by the next generation of wolves, as the adults pass on the experience to the young wolves in their pack (e.g. Packard 2003, Langenhof and Komdeur, 2018).

Materials and methods: The electric sheep collar is aimed to be practical, effective, reusable (resistant to mechanical and weather effects) and affordable, as each sheep of the flock needs to have one. It must not discomfort, injure or behaviourally restrict the sheep wearing it, nor other animals in the herd. The current prototype was developed during four pasture seasons. It consists of two parts, a textile part (TP) holding an electromechanical part (EMP). The EMP is activated by the bite of a wolf and should trigger a short, high voltage pulse to the wolf's oral cavity, jaws and/or teeth. The pulse is meant to deter and not to injure the wolf. Therefore, the values of pulse energy, duration and maximum voltage are chosen well below any threshold that might cause health problems (e.g. heart fibrillation, convulsions, or burns). Moreover, the electrodes of the EMP are made of soft material to avoid wolf tooth damage.

Results: A working, patented (SI 25485 A) prototype of an electric collar for sheep was developed (Fig. 1) The most suitable textile as tested over two pasture seasons was vapour-permeable elastic fabric that dries quickly and is antibacterially treated. It did not cause any changes to the underlying skin and/or wool. It also fulfilled the other requirements. The fit of the collar and its position was maintained by the elasticity of the fabric, combined with a flexible binding, a band and the position and weight of two EMP's. Two EMP's are attached to one collar to ensure that the wolf bites in and triggers an EMP. The EMP consists of a linear, single degree of freedom mechanism (SDOFM), and an electric pulse generator (EPG). The SDOFM provides the reliability by ensuring that the EPG is triggered once at any direction of the compression force caused by the bite, while preventing a false trigger. It also returns in start position after the wolf releases the bite. A reliable, low-cost, fully autonomous, battery-free EPG is built into the SDOFM. Each bite triggers one pulse of max 25µJ. The shock is not perceived by the sheep. The EMP has been tested in the laboratory but not yet in the field.

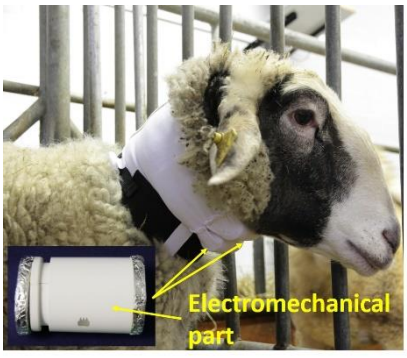


Figure 1. Sheep electric collar

Conclusion: A new approach to sheep protection is presented along with a detailed description of the patented prototype of sheep electric collar. The ergonomic functionality of the collar has been tested and confirmed. In order to consider the proposed approach as a protection measure, a test of collar effectiveness should be performed in the field. If a drop in annual wolf attacks and sheep killed per attack is confirmed, this collar has a significant added value to protect herds in areas where current methods cannot be applied (e.g. alpine pastures). Its value in combination with existing methods can also be considered.

Characteristics and risk factors of predation by large carnivores on domestic herbivores in Valle Camonica (Italy)

Bonettini A.[1], Tavelli P.[1], Eterovich A.[1], Baglioni S.[2], Mirra G.[2], Lo Russo F.[2], Mattiello S.[2]

1. Technology Transfer Centre, Fondazione Edmund Mach, Via E. Mach 1, 38010, San Michele all'Adige (TN), Italy. 2. Department of Animal Medicine, Production and Health, University of Padova, Viale dell'Università 16, 35020, Legnaro (PD), Italy; erika.partel@fmach.it

Keywords: wolf, brown bear, sheep, cattle, mountain pastures

Introduction: In the last 20 years, predation has become a concern for mountain animal husbandry in Italy. In Valle Camonica (Central Italian Alps), the first report of the presence of brown bear dates back to 2000, whereas wolves appeared in 2014 and established the first pack in 2019. The present survey was carried out in order to highlight the characteristics and risk factors of predation by bears and wolves on domestic herbivores grazing in Valle Camonica, with the aim of acquiring a deeper knowledge of the problem and of its perception for planning suitable mitigation actions.

Materials and methods: Between August and October 2020 we carried our direct interviews in 46 farms that make use of summer pastures. The questionnaire included questions on: a) farm characteristics and management and on the preventive systems adopted; b) presence of predators in the area and occurrence and characteristics of predation events; c) effectiveness of the prevention methods adopted and satisfaction about their use; d) farmers' perception about predators' presence.

Results: A total of 24 predation events was reported, for a total of 28 animals killed (19 sheep, 6 lambs, 3 calves), plus 114 animals lost (108 sheep, 6 lambs). More than 30% of the farms (14/46) declared to have suffered from at least one predation event, but two farms reported up to 4 events in the period 2010-2020. The frequency of the events has been increasing, reaching its top in 2020. The events are concentrated between May and September, during the summer grazing period. Most of the events (41.7%) were attributed by farmers to wolves, 29.2% to brown bear and the rest to unknown predators. However, only 66.7% of the events was officially reported, and the responsibility of the predator could be confirmed only for 60% of the events attributed by farmers to wolf and for 29% of the events attributed by farmers to bear. The average number of animals killed or lost is 2.2 heads in case of events attributed by farmers to wolf, and 3.2 heads for events attributed to bear. The presence of predators is perceived as a problem by 76.1% and 73.9% of the farmers for wolf and bear, respectively. In spite of this, only 6.2% of the respondents declared to know the relevant legislation for the protection of livestock subject to predation and only one farmer was in favour of the financial support for the implementation of prevention systems, while 16 farmers (34.8%) were in favour of wolf culling and 13 (28.3%) were in favour of bear culling.

On average, farms that suffered from predation events are those with a larger total and grazing surface area (t test: $p<0.01$), a higher number of animals (t test: $p<0.01$) and a higher number of animals/number of stockmen ratio (t test: $p<0.05$). Furthermore, predation was more frequent during the alpine pasture period and in farms where there are no full-time operators (chisq test: $p<0.05$).

Preventive systems (guardian dogs, night shelters or electric fences) are adopted only by 15.2% of the farms, especially by those that had previously suffered from predation. Most of these farmers declared to be satisfied of the methods, as they helped to limit predation events.

Conclusion: Predation by large carnivores seems to be an increasing issue in Valle Camonica, and certainly deserves attention. The knowledge of the distribution of wolves and bears within the Valley and the identification of risk factors are essential to mitigate the conflict, and may be helpful to drive support actions from public bodies. Furthermore, in order to provide public bodies with a clear and realistic vision of predatory dynamics, it is essential to encourage farmers to correctly report predation events and signs of presence of the predators. Finally, it is interesting to remark that farmers seem to be averse to change the way they manage their herds, and are not prone to adopt prevention methods. The promotion of campaigns to disseminate good farming practices and the use of preventive measures plays therefore an essential role for mitigating the conflict.

Attitudes of local and general populations towards agriculture, the environment and economic development in mountain areas

Muñoz-Ulecia E.[1], Bernués A.[1], Ondé D.[2], Sturaro E.[3], Martín-Collado D.[1]

[1]Unidad de Producción y Sanidad Animal. Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA), IA2 (CITA-Univ. de Zaragoza). Avda. Montañana 930, 50059, Zaragoza (SP)
[2]Dpto. de Psicobiología y Metodología en Ciencias del Comportamiento. Univ. Complutense de Madrid. Campus de Somosaguas. 28223, Pozuelo de Alarcón. Madrid (SP). [3]DAFNAE, University of Padova, Viale dell'Università 16, 35020 Legnaro, Padova (IT); emunnozul@cita-aragon.es

Keywords: attitudinal dimensions; psychometric analysis.

Introduction: There is a growing debate about the future of European agriculture mainly represented by the Productivity and the Sufficiency narratives (Mathijs, 2020 in Herren et al, 2020). Productivity narrative is based on economic growth as the only way forward to deal with scarcities, while Sufficiency narrative focuses on the limits to growth imposed by the Earth's finite resources and carrying capacity (Mathijs, 2020 in Herren et al, 2020). Scientific knowledge, social demands and policy agreements at national and international levels commonly determine how rural populations at local level have to adapt their activity. Different worldviews underlay the variety of perspectives regarding the proper path for agriculture (i.e. productivism, multifunctionalism, organic, etc.), which create dispute between different social groups and stakeholders. Furthermore, social perception may vary between local inhabitants or rural areas and society in general, and among different social groups within these areas. General attitudes towards agriculture, the environment or economic development play a key role in ecosystem services valuation as showed by Rodriguez-Ortega et al. (2016). In this study, we made a comparative study in the Spanish Pyrenees and the Italian Alps, using an approach based on standardized psychometric methodologies to evaluate attitudes. Specifically, we aimed to (i) determine the attitudinal dimensions that build people views towards agriculture, environment, and economic development and their trade-off and synergies, and (ii) compare the attitudinal dimensions of rural and urban inhabitants.

Materials and methods: We analysed two case study areas: 'Sierra y Cañones de Guara' Natural Park in the Spanish Pyrenees and Trento province in the Italian Alps. A survey was conducted in both people living inside the areas ("local" population) and in the neighbouring villages (i.e. "general" population). For the general population, 804 people over the age of 18 (50% in case study area) were interviewed in a professional online panel that was representative of the adult population. For the local population, a representative sample of 204 people (50% in each area) were surveyed in face-to-face interviews. The survey included 20 Likert-type questions (5 response categories) that focused on attitudes towards (i) economy and the environment, (ii) rural development and agricultural intensification, (iii) food quality, production, and consumption and (iv) agricultural and environmental policy. We performed exploratory factor analysis to deepen into the inner attitudinal structure of respondent towards the above-mentioned aspects, by determining social constructs (i.e. attitudinal dimensions or factors). Finally, we analysed (ANOVA test) the differences in attitudinal dimension across local and general populations and across countries.

Results: The exploratory factor analysis showed four different factors representing social constructs that underline perceptions and attitudes. Factor 1 (Economic Liberalism, EL) represented attitudes towards the generation of economic wealth above environmental policies and conservation. Factor 2 (Mass-market Agriculture, MA) grouped attitudes towards industrial product transformation and large supermarkets rather than local and traditional stores. Factor 3 (Intensive Agriculture, IA) represent positive attitudes towards intensive agriculture and productivism. Finally, Factor 4 (Environmental Worldview, EW) related to general pro-environmentalism attitudes, and the support of environmentally friendly agriculture and rural life.

We observed statistical difference in the four attitudinal factors between Spain and Italy ($P<0.05$). However, when comparing local and general populations between countries we found that local populations only differed in the IA factor (higher values in Spain, $P<0.001$), while general populations showed differences in the other three factors (higher values in Italy, $P<0.05$). Each country also showed differences between populations. In Spain, local population showed higher values of IA and EW factors than general population ($P<0.01$). In Italy, local population showed lower values than general population in EL, and MA factors, and higher values of EW factor ($P<0.01$).

Conclusion: Local populations in the Pyrenees and the Alps showed a higher attitudinal support towards environmentally friendly agriculture than the general population. Interestingly, the local population in the Pyrenees also supported intensive agriculture and productivism which shows that they do not see an incoherence between environmentally friendly agriculture and intensive agriculture.

Summer mountain grazing has a long tradition in the Alpine region

Dovč P.[1], Ashja A.[1], Klopčič M.[1], Zorc M.[1]

[1] University of Ljubljana, Biotechnical Faculty, Department of Animal Science, Jamnikarjeva 101, 1000 Ljubljana, Slovenia; peter.dovc@bf.uni-lj.si

Keywords: mountain grazing, genetic resources, ecological service, traditional animal production

Introduction: Grazing with ruminants during the summer is a common practice in many mountain areas. It is a strategy on how to make use of marginal agricultural land and to extend the limited surface available for food production in these areas. Summer mountain grazing has a positive effect on animal's health and longevity. Seasonal use of mountain pastures has a long history and was systematically promoted and surveyed already at the end of the 19th century. In this paper, we refer to historical documents describing the support of summer grazing practices in the Habsburg Monarchy at the regional and state level (Schuppli, 1909), published reports about production efficacy on community mountain pastures during the summer periods in three consecutive years (Kosterz and Weininger, 1908), and compare them with the current production data in Slovenia (Žvikart and Dular, 2013) and Spain (Casasus et al., 2002).

Materials and methods: Based on old documents describing organisation, economic evaluation and social relevance of summer mountain grazing in the Alpine area, the comparison with contemporary situation was performed. The importance of summer grazing from agricultural, environmental and social point of view in present time and in the past was surveyed. The possible social conflicts resulting from agricultural use of land in the mountain areas in circumstances are addressed.

Results: The success of summer grazing is highly dependent on environmental factors as well as on the adaptability of the animals used for this purpose. Therefore, mountain grazing has been instrumental in the development and maintenance of numerous local breeds of different species with good adaptive potential to the specific environmental conditions at high altitude. Despite the fact that the economic profit has fluctuated greatly from year to year in the past and is subject to significant fluctuations also in the present, the importance of this production strategy for the national agricultural production remains very important. Moreover, the contribution of summer grazing to the local eco-service activities, that ensure the conservation of cultivated land in mountain areas, also supports some non-agricultural activities, such as tourism and the conservation of biological resources.

Conclusion: Summer grazing in mountain areas has a long history, and in the past represented an opportunity to expand the area of land used for agriculture. In addition to this objective, the eco-service and the conservation of genetic resources are gaining in importance as a result of this activity.

How can satellite technologies prevent livestock predation and mitigate excessive damage from large carnivores?

Frangini L.[1], Franchini M.[1], Filacorda S.[1]

[1]Dipartimento di Scienze Agroalimentari, Ambientali e Animali, Università di Udine, 33100 Udine, Italy; lorenzo.frangini@uniud.it

Key words: large carnivores, conflicts, GPS collars, virtual fences, proximity sensors

Introduction: Today the important role of mountain farms in the maintenance of historic traditions and ecological balance, promoting tourism and providing ecosystem services, is widely recognized. However, the main disadvantage is related to the absence of farmers surveillance, which may lead to interactions with wildlife. On the other hand, conflicts between large carnivores and livestock activities is one of the main factors which have led to the decline of predators worldwide. As far as concerns conflicts' management, it was stated that killing off predators could not be the best solution in the long term, whereas non-lethal methods (e.g., guarding dogs, fences) represent a better choice. New methods for wildlife and livestock monitoring such as satellite tags and their equipped sensors, thus could represent a useful solution in terms of human-predator conflicts mitigation. In this sense, since GPS collars can use virtual fences (i.e., user defined areas within which a remote alarm will be triggered if the predator enter within it) and proximity sensors (i.e., sensors that enable to study inter- and intraspecific interactions), may represent a useful tool for conflict mitigation. The purpose of the present work was to present some preliminary data regarding the use of GPS-GSM collars as tool for human-carnivore conflict mitigation using the Brown bear (*Ursus arctos*) as a reference species. Specifically, we wish to evaluate any individual and/or age-related difference in terms of recorded damages, and to provide further insights on how these technologies can favour large carnivore mitigation.

Materials and methods: The study was carried out in the Friuli Venezia Giulia (FVG) region (north-eastern Italy), which can be considered as the expansion area for two brown bear populations living in the Dinaric and Central Italian Alps. Within the region at least five different individuals (all males) have been detected every year. From 2007 to 2018 seven young and adult bears (3-10 years old) were captured and fitted with GPS-GSM collars equipped with both temperature and activity sensors (dual- or tri-axial accelerometers). GPS locations were recorded within a period ranging from 15 min. up to six hours. When a damage due to a collared bear occurred, we warned the stakeholder about bear presence.

Results: We obtained 24,976 GPS locations and the analysis revealed that two out of seven bears showed predatory behaviour. One adult individual (ten years old) mainly preyed on sheep, goats and deer, while another (eight years old), which came from Central Italian Alps and classified as a 'conflict bear' due to its preference for preying on livestock, progressively reduced its predatory impact. Nevertheless, during the last monitoring year (2019) new livestock predation events (i.e., sheep) were recorded. Furthermore, three bears out of seven showed a strong latency to attack beehives. On 14 out of 17 bear damage events stakeholders did not experienced any other damage in the short period.

Conclusion: We captured and collared a consistent number of bears compared to the overall genetically identified individuals which have roamed within the region since 2003 (n = 7, 19%). Analyses on damages highlighted that, despite data were collected from few bears, predatory behaviour could be linked even for both individual and age effect, in accordance with other studies performed on brown bear. Furthermore, most of stakeholders who were warned did not experienced damages anymore. These preliminary findings suggest that the use of advancing satellite technologies may be adequate in reducing livestock killing. Radio-tracking of problematic individuals will enable researchers and farmers to apply virtual fences around mountainous farms to reduce the risk of livestock predations by detecting carnivore-livestock interactions before the attack. Further applications may refer to the use of GPS collars with proximity sensors to both predators and livestock species to efficiently prevent damages.

Red deer (*Cervus elaphus*) grazing on permanent grasslands in Triglav National Park

Lukač B.,[1], *Vidrih M.*[2], *Bertoncelj I.*[3]

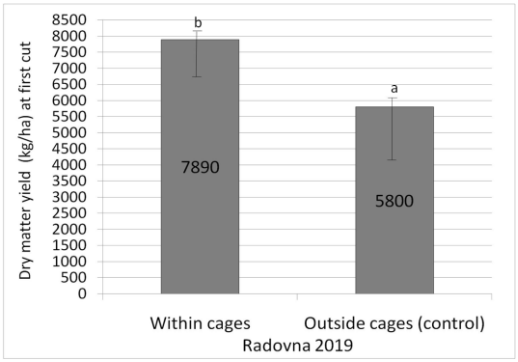
[1] *Crop Science Department, Agricultural Institute of Slovenia, Hacquetova ulica 17, 1000 Ljubljana, SI;*
[2] *Biotechnical Faculty, University of Ljubljana, Jamnikarjeva ulica 101, 1000 Ljubljana, SI*
[3] *Department of Agricultural Ecology and Natural Resources, Agricultural institute of Slovenia, Hacquetova ulica 17, 1000 Ljubljana, SI; branko.lukac@kis.si*

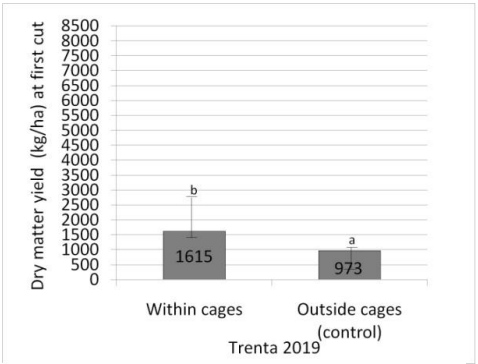
Keywords: wild ungulates, forage consumption estimation, dry matter yield, permanent grassland

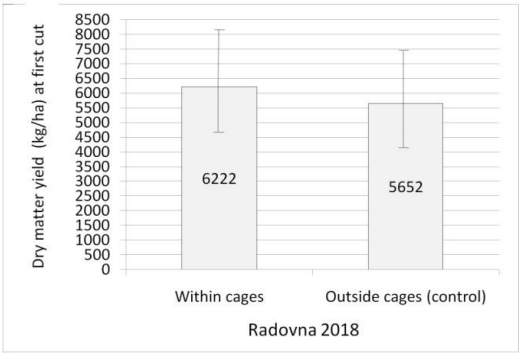
Introduction: In recent years, complaints from farmers about damage to permanent grassland in the spring months due to excessive grazing by wild ungulates have increased significantly, especially in protected areas such as the Triglav National Park (TNP). Therefore, we set up a field experiment on two farms within TNP in spring 2018 and 2019 to assess yield losses due to red deer (*Cervus elaphus*) grazing during the growing season.

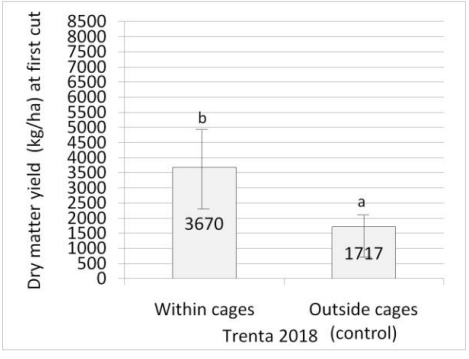
Materials and methods: Grassland sites on the farms studied differed in intensity of grassland management and botanical composition. In spring, 10 wildlife-proof cages made of iron mesh with a lid were placed at each site. All plants growing within the cages and in 10 unprotected control plots (1 m^2) were harvested at spring cutting. Cutting and sampling dates were adjusted to activities on both farms. Spring cutting at Radovna was earlier in both years (1/6/2018 and 6/6/2019) compared to Trenta (19/6/2018 and 5/6/2019). The amount and consumption of forage were evaluated by comparing the plant biomass inside and outside the cages. Harvested plants were dried and weighed to estimate dry matter yield. Data were analysed with Statgraph using Student's t-test.

Results: Average dry matter yields and differences in harvested plant biomass inside and outside cages varied among sites and subsequent years. The results showed a decrease in forage yield on permanent grasslands ranging from 9.2 to 53.2% in Radovna and Trenta.









Conclusion: The losses recorded in our experiment are considerable and have a great influence on the forage production and the forage available for winter livestock on both farms. The extent of losses varied considerably between years, probably due to weather conditions within the growing season and the availability of food for wild ungulates in the surrounding forest and at higher altitudes.

Session 3: Precision mountain farming and smart agriculture

Take home messages

from oral and poster presentations

Animal-carried sensors in mountain livestock science: opportunities and challenges
Schneider M. K., Pauler C. M., Bérard J.
Animal-borne sensors offer to monitor activities of grazing animals continuously over long time without disturbing their natural behaviour. They can therefore provide novel insights into mountain livestock behaviour. However, most devices need careful adaptation to the harsh mountain environment.

Application of Virtual Fencing for the management of Limousin cows at pasture during spring-summer season: preliminary results
Confessore A., Aquilani C., Nannucci L., Bellini E., Argenti A., Staglianò N., Moriondo M., Dibari C., Semenzato P., Nicoloso S., Pugliese C.
Virtual Fencing is new interesting technology to manage cows at pasture.

Can research benefit of real-time GPS collars conceived for livestock management by farmers?
Pittarello M., Nota G., Probo M., Svensk M., Lombardi G.
Real-time GPS collars, equipped on all animals of the herd, are conceived for livestock management by farmers. Nevertheless, as they provided comparable results to conventional GPS collars regardless of a low acquisition rate, they can be used for research on livestock spatial distribution.

ResNatSeed: A tool for the assessment of the REStoration potential of NATive SEEDs based on topographic factors in Piedmont Region, Italy
Barberis D., Pittarello M., Lombardi G., Lonati M.
We would like to present a methodology we developed with the aim of estimating the potential success of native seed mixtures on given restoration sites according to their topographic characteristics. We are therefore trying to apply ecological knowledge on the practical restoration activities.

Communicating knowledge on alpine pasture management to farmers using videos and the internet

Schneider M., Mettler D., Alföldi T., Willems H., Werder C.

Communicating with farmers by means of video and web content is a contemporary means of knowledge transfer. The website https://www.patura-alpina.ch was released in summer 2019 to communicate information about the management on alpine pastures.

Daily energy expenditure for locomotion by sheep in the Pyrenean summer mountain grasslands

Larraz V., Reiné R. , Barrantes O., Fillat F

The aim of this study was to evaluate the energy expenditure for locomotion by sheep in the Pyreneen summer mountain grasslands. Knowledge about activity and behaviour of free-ranging sheep may contribute to an efficient management of mountain pastures.

The "Animal Sense" warning system. Low-cost technology to prevent collisions between semi-domestic reindeer and vehicles

Hansen I., Eilertsen S. M., Jørgensen G. H. M., Karlsson J.

Collisions between semi-domestic reindeer and vehicles is an increasing problem. The new, low-cost "Animal Sense" electronic warning system shows promising results regarding preventive effect, energy efficiency and use of materials that can withstand a harsh Arctic winter climate.

VegeT: An Easy Tool to Classify and Facilitate the Sustainable Management of Seminatural Grasslands and Dynamically Connected Vegetation of the Alps

Leoni V., Giupponi L., Pedrali D., Rodari A., Giorgi A.

The aim of the study was to create a software tool to assist land managers in the sustainable management of Alpine grasslands, facilitating the interpretation of the floristic-vegetation datasets.

Current state of the art for the use of Earth Observation in grassland management: a practical guide

Green S[1].

[1]*Teagasc, Rural Economy & Development Programme, Ashtown, Dublin, Ireland; Stuart.Green@teagasc.ie*

Keywords: Earth Observation, Grassland

Introduction: Earth observation, EO, technologies have developed around agriculture since the launch of LANDSAT in 1972. For most of that time, first with satellites and now with drones, croplands were of principal concern in the EO/precession agriculture space and grasslands were explored more as ecosystems to be monitored for exploitation. Now the growth of digitisation on grassland farms, driven by intensive dairy systems, has lead to a new interest in grasslands as an EO target.

This review of the current level of commercial services and operational monitoring systems in grasslands show how the EO community is slowly understanding the particular needs of the grassland farmer, looking for information on current growth rates for example, or soil trafficability. The grassland farmer is less interested in variations within a paddock (as a tillage farmer may be interested in variation within a field) than between paddocks and variation over the course of a season. The new focus on using EO to manage intensive grasslands, whilst supporting grazing over housing of animals, is in danger of leaving many grassland farmers behind and ignoring the technical achievements gained when viewing grassland as biodiversity issue though an EO lens.

The review highlights current commercial capacity in EO for grassland management and explores new technologies on the horizon critically in the context of EO serving European grassland farmers.

Materials and methods: A non-systematic review of commercial services available to grassland farmers in academic literature and grey commercial literature.

Results: There has occurred in the last 10 years a shift in emphasis in the earth observation community from grassland as an ecosystem to grassland as a crop. This has in turn driven the adoption of EO technology into the commercial sphere of precession agriculture of grasslands. Many of the services are adaptations of systems built for croplands and as such do not always meet the needs of grassland farmers. Earth Observation technologies can support the farming of European grasslands and the grazing of livestock.

Conclusion: Some EO products are approaching a full service grassland management solution from space but address only the needs of a relatively small cohort of intensive, high productivity farmers. As a result the majority of European grassland farmers could face a growing digital divide.

Animal-carried sensors in mountain livestock science: opportunities and challenges

Schneider M. K.[1], Pauler C. M.[1], Bérard J.[2, 3]

[1] Forage Production and Grassland Systems, Agroscope, Zurich (CH); [2] Animal Production Systems and Animal Health, Agroscope, Posieux (CH); [3] AgroVet-Strickhof, Lindau (CH); manuel.schneider@agroscope.admin.ch

Keywords: Sensors, global positioning systems, pedometers, nose-band pressure sensors

Introduction: The past 50 years has seen great advancement in the use of electronics in agriculture (Hostiou et al. 2017). 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 also in outdoor environments (Ropert-Coudert and Wilson, 2005). To know where animals are and what they do allows mountain farmers and researchers to better design sustainable livestock production systems. In this contribution, we therefore focus on the challenges and opportunities arising in mountain environments and aspects to consider when using sensors in mountain livestock research.

Materials and methods: From 2015 to 2018, two controlled grazing experiments were conducted on alpine pastures in the Eastern Swiss Alps (1900-2200 m asl., 0-150% inclination). GPS trackers (Qstarz, Taipei, Taiwan), pedometers (IceRobotics, Edinburgh, Scotland) and nose-band pressure sensors (MSR Electronics, Seuzach, Switzerland) were fitted to sheep, goats and cattle of four breeds (Dexter, Highland cattle, Original Braunvieh and Angus x Holstein). GPS data were used to quantify movement activity according to constraints such as slope and vegetation composition. Pedometers measured the number of steps and leg orientation. Jaw movements were used to estimate grazing and rumination time as well as the intensity of chewing. All sensor activities were complemented by simultaneous visual observation of key activities.

Challenges: Halters of sensor devices are usually designed for one animal species and size class. Fitting them to smaller or larger animals can be challenging or difficult, especially if the quality of the sensor signal strongly depends on an accurate fitting to the animal's body such as with a nose-band pressure sensor. Moreover, certain breeds or individuals may have a special head anatomy which requires adjustments of halters. Finding a skilled craftsperson to adjust the halters can be tricky, costly and time-consuming.

The harsh environmental conditions in mountains (regular frost during night and high levels of solar radiation during the day) can severely damage electronic devices. Regular status updates during deployment is essential but often come at the price of substantially increased device cost and battery consumption. Moreover, animals roaming remote terrain regularly get in contact with rocks and branches and may lose their sensors.

Mountains constitute a serious obstacle for remotely transmitted data such as GPS or mobile radio. Satellite-based augmentation systems like EGNOS are inaccessible in locations shaded towards South. Data quality may be low and uncertainty large. Assessing the quality and quantifying the uncertainty is challenging since most of the simpler GPS receivers for example do not record a consistent set of quality indicators.

In operational mode, all electronic devices generate data, but it is up to the user to assess their accuracy. This is especially demanding in fully-assembled devices with internal data interpretation, such as pedometers or GPS trackers. Without access to the raw data, a full capture of uncertainty and data correction in case of inaccuracies is difficult or even impossible.

Finally, even if data uncertainty has been quantified or estimated, considering it appropriately in subsequent analyses is challenging. Although statistical techniques to account for uncertainty in input data are available (e.g. Kery & Royle 2016), they require advanced skills and are computationally demanding for large datasets. Hence, even substantial data uncertainty is often ignored in sensor studies.

Opportunities: Animal-carried sensors offer the opportunity to monitor activities of grazing animals continuously over long time periods without disturbing their natural behaviour. This makes sensor advantageous over direct observations, which are time-consuming, subjective and disturbing. Moreover, sensors allow to monitor processes which are not directly observable by humans.

Sensors offer data at high temporal resolutions. Since data storage capacity has been increased in recent years, it is possible to store raw data of multiple channels for several days to weeks (e.g. 20 Hz accelerometer data for several weeks). This offers a wealth of opportunities to develop new algorithms for data interpretation.

Conclusion: Animal-carried sensors offer new insights into mountain livestock behaviour. However, most devices were developed for in-house deployment and need careful adaptation and testing for their application in the harsh mountain environment.

Application of Virtual Fencing for the management of Limousin cows at pasture during spring-summer season: preliminary results

Confessore A.[1], Aquilani C.[1], Nannucci L.[1], Bellini E.[1], Argenti A.[1], Stagliano N.[1], Moriondo M.[1], Dibari C.[1], Semenzato P.[2], Nicoloso S.[2], Pugliese C.[1]

[1] DAGRI, Univ. Firenze, IT; [2] DREAM Italia Soc. Coop. Agr., IT; andrea.confessore@unifi.it;

Keywords: Virtual Fencing; Cows; Precision livestock farming; Extensive farming; New technologies

Introduction: Virtual Fencing (VF) represents a newly helpful technology to manage herd in extensive livestock systems. In VF system, traditional physical fences are replaced by virtual ones and, when the animals approach the boundaries, they receive a paired stimulus: an audio cue followed by a low electrical shock when animals are close to the virtual fences. If animals continue to walk forward, they receive a maximum of three consecutive low shocks, until they return to the virtual grazing area. The study aims are: i) to evaluate the animal's ability to learn, and so, to avoid the adverse stimulus; ii) to evaluate the efficiency of the system to manage the herd within grazing areas virtually delimitated.

Materials and methods: The study area was a pasture located in Mugello (Tuscany). The entire pasture surface was uniform, and no slopes were present. The study took place in the spring summer of 2020 (6-24 July 2020). Twenty Limousin cows were endowed with VF-GPS collars (Nofence AS, Batnfjordsør, Norway). Before the trial started, for eight days (T0), the collars were inactive to let the animals get acquainted with them, with free access to the entire pasture area (approximately 20 ha). After that, an experimental step trial was conducted by widening the grazing area via VF boundaries. For the first Trial (T1) virtual fences were settled approximatively at 40% of the total surface (8 ha) for three days. Then (T2), the boundaries were moved up to 60% of the total area (12 ha) for four days. For the last trial (T3) boundaries were shifted longitudinally to the pasture area for three days, to restrict the pasture along one side (13 ha). Total number of sounds emitted by the collars (S), total number of shocks delivered by the collars (Z), length of sounds (ms) emitted by the collars without the animals receiving the shocks (Wd), number of times animals escaped from the virtual grazing area (E), were the parameters recorded. Moreover, differences between walking activity, in terms of number of steps performed by the animals per hour (Wa), among trials was evaluated, as well as the ratio between number of Z and S (Z/S). All data were analysed using general linear model of SAS Software, and the unit of analyses was average/animal/trial.

Results: Results show a significant difference either in S, with T1 (29.95) and T2 (26.40) differing from T3 (9.47) ($P<0.0001$) and in Z, with T1 (15.88) which showed the highest and T3 (4.13) the lowest number of zaps, respectively ($P<0.0001$). Significant difference was also observed in E among the three sessions (T1= 3.06 vs T2 = 1.60 vs T3 = 0.90, $P< 0.0001$). Moreover, Wd was significantly reduced in the last session (T1 = 65483 ms and T2 = 83413 ms vs T3 =26319 ms vs, $P<0.0002$). Lastly, a reduction ($P<0.0250$) in the Z/S ratio was observed between T1 (0.54) and T3 (0.37), with T2 (0.41) being similar to both, $P< 0.0001$) and in (Wa) between trials (T0 mean 657 ± 12 vs T1 mean 742 ± 28 vs T2 mean 917 ± 19 vs T3 mean 718 ± 26). The lesser S and Z occurred during T3 seem correlated with the animals' positive response to the system. It was also confirmed by the Z/S ratio. The progressive decrease in E indicate the animals' attitude to stay within the virtual boundaries. Furthermore, cows were more responsive to the audio cue in T3, indeed, thanks to their previous experiences, they learn to turn back quickly before taking a shock. Finally, walking activity, as number of steps, was the lowest in T0, increased in T1 and T3. While, the highest Wa was recorded in T2.

Conclusion: The differences observed in the studied parameters between following sessions, suggested that animals were able to learn how to correctly interact with the VF system, and therefore the effectiveness of such technology in managing beef cows at grazing.

Can research benefit of real-time GPS collars conceived for livestock management by farmers?

Pittarello M.[1], Nota G.[1], Probo M.[2], Svensk M.[2], Lombardi G.[1]*

[1] University of Torino, Department of Agricultural, Forest and Food Sciences (DISAFA)
[2] Grazing Systems, Agroscope, Nyon, Switzerland; marco.pittarello@unito.it

Keywords: spatial distribution, grazing behaviour, livestock tracking, resource selection, GIS

Introduction. In the last 20 years, the advent of global positioning system (GPS) collars has greatly enhanced the research on livestock spatial distribution in rangelands. Conventional GPS collars (CC) are used on sample animals whose positions are recorded on-board at a high acquisition rate, even in rough environments. In the last few years, real-time position monitoring collars (RTMC) have been developed to support livestock management by farmers. They are generally equipped on all the animals of the herd and transmit the positions to an antenna, which sends the data to a server via GSM network. Farmers can check animal positions in real time by using a smartphone or personal computer. The aim of this study was to evaluate if data gathered by RTMC in rough mountain pastures fulfil research needs to assess vegetation community selection by livestock and the factors affecting livestock spatial distribution with a similar pattern to CC data.
Materials and methods. In summer 2020 (Vogna valley - NW Italian Alps), all adult animals (51 cows) and 7 adult cows from a herd of 68 Highland cattle were equipped with RTMC (30-min recording interval) and CC (10-min recording interval), respectively. Within a paddock of 59 ha, 24 vegetation surveys using a vertical point quadrat method (Daget and Poissonet, 1971) were carried out to identify the main vegetation groups. Forage Pastoral Value was calculated according to Daget and Poissonet (1971). The GPS fixes for RTMC and CC for the period 10/9-21/9 were selected. Preference indexes for each vegetation group were computed as the proportion of GPS fixes within a group divided by its proportional area (Manly et al. 2002). To study livestock spatial distribution, the paddock was subdivided into 10×10m grid cells and the number of RTMC and CC fixes were counted within each cell. The counts were modelled as a function of vegetation and topographic variables, i.e. green alder (*Alnus viridis*) cover, Pastoral Value, slope, and the distance from water sources using Generalised Linear Models.
Results. Even though the number of animals equipped with RTMC and CC and the recording interval were different, the number of recorded fixes was similar (12871 and 12093 overall, respectively), mainly because of the lower acquisition rate of RTMC (48.92% ± 2.2, mean ± se) compared with CC (99.98% ± 0.02). RTMC are not provided with an on-board memory and communication failure with the antenna results in data loss. However, preference indexes and the effect of factors affecting livestock spatial distribution were highly comparable between the RTMC and CC (Fig 1).
Conclusions. Since RTMC were not equipped with an internal memory, data loss affected the acquisition rate negatively. Nevertheless, being almost all the animals equipped with RTMC, the overall conclusions derived from research results were comparable to those provided by CC. Installing an internal memory would improve the representation of the entire herd spatial distribution.

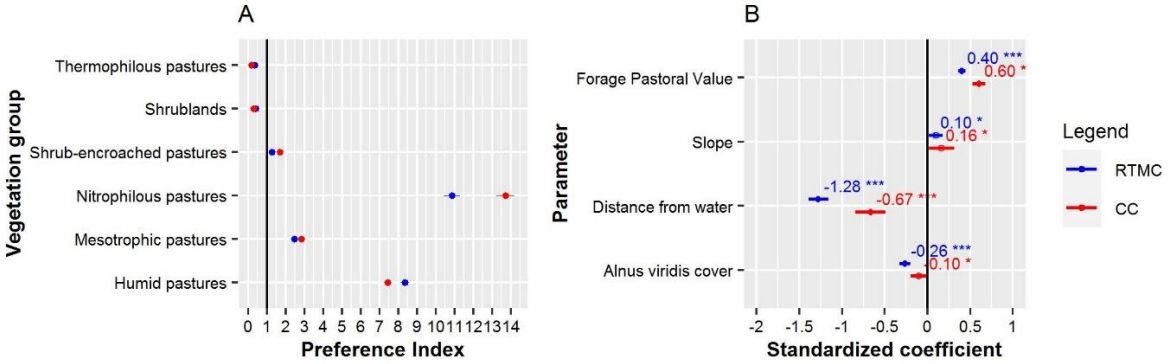


Figure 1. A) Preference Indexes for each vegetation group and B) results of Generalised Linear Models showing the effects of vegetation and topographic variables on spatial use by livestock with real-time position monitoring collars (RTMC) and conventional collars (CC), respectively.

ResNatSeed: A tool for the assessment of the REStoration potential of NATive SEEDs based on topographic factors in Piedmont Region, Italy

Barberis D.[1], Pittarello M.[1], Lombardi G. [1], Lonati M.[1]

[1] *Department of Agriculture, Forest and Food Sciences, University of Torino (IT); d.barberis@unito.it*

Keywords: restoration ecology, vegetation, elevation, native seeds

Introduction: Native seeds are increasingly recognized as the best material for Restoration Ecology. However, it is challenging to understand the level of suitability of a mixture harvested from a donor grassland for a certain restoration site. The methods of assessment usually used are expert-based and focus on the similarity between the climatic and topographic factors of the two sites. Moreover, the vegetation survey of the donor site provides a useful overview of the expected seed mixture composition. The aim of the work was the development of a tool in R environment (R Core Team, 2019) to assess the potential suitability of a seed mixture to the receiving site, starting from some easily measurable topographic factors: elevation, slope and aspect.

Materials and methods: An algorithm was developed to model with Generalized Additive Models (GAM) the potential maximum abundance for each species of the donor site. The complete algorithm workflow is reported in Figure 1. The modelling process uses a database with 3839 surveys performed to classify the alpine pastures of the Piedmont Region (Cavallero et al., 2007), containing a complete list of species, their abundance and the values of elevation, slope and southness. The three topographic variables were divided into classes and for each species and class the survey with the maximum abundance of that species was selected. This allows to assess the potential maximum abundance that the species can reach for that specific class. All the selected surveys were merged excluding duplicates from the three topographic factors. The obtained dataset is used to predict the maximum abundance and the expected abundance for each species at the restoration site.

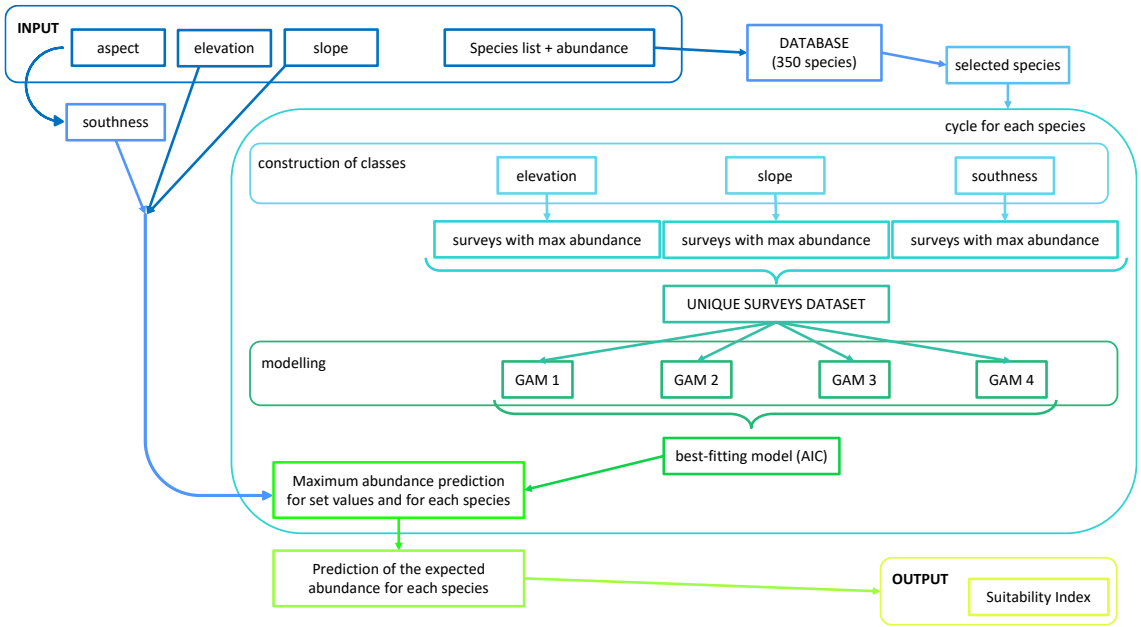


Figure 1. Workflow of the algorithm.

Results: The input of the seed mixture composition (or that of the donor site) and of the topographic factors of the restoration site, allow to calculate the Suitability Index, dividing the predicted expected abundance by the abundance in the mixture. The index ranges from 0, not suitable, to 1, perfectly suitable.

Conclusion: This method can be applied to every geographic area where a large number of surveys is available for a reliable modelling. The system uses the software R, but can be implemented on easier to use interfaces to allow also non-experts of the software R to use the algorithm for restoration purposes. This method is based on existing vegetation data, and its reliability still needs to be validated in the field.

Communicating knowledge on alpine pasture management to farmers using videos and the internet

Schneider M.[1, 2], Mettler D.[3], Alföldi T.[4], Willems H.[5], Werder C.[5]

[1] Agroscope, Zürich, Switzerland; [2] Swiss Grassland Society, Zürich, Switzerland
[3] Agridea, Eschikon, Switzerland; [4] Research Institute of Organic Agriculture (FiBL), Frick, Switzerland
[5] Büro Alpe, Lätti, Switzerland; manuel.schneider@agroscope.admin.ch

Keywords: extension, education, multimedia, pasture management, weed control

Introduction: Alpine pastures cover 11% of Switzerland and one third of its agricultural area (Lauber et al. 2013). They provide important ecological and cultural values and are important for the Swiss identity. Therefore, direct payments to alpine summer farms require careful management of pastures in order to maintain biodiversity, openness and beauty. Pasture management is regularly controlled by certified inspectors. Because of its seasonal nature, labour on alpine pastures is frequently carried out by external staff without formal training. Staff sometimes changes on an annual base, impeding the accumulation and transfer of knowledge. Because advisory documents concerning pasture management and especially weed control are scattered in different formats and from different organisations, we jointly set up a project to synthetize existing knowledge about specific problems which frequently occur on alpine pastures. Because the internet is increasingly used as a source of knowledge, we aimed at disseminating this information by means of a new website and educational videos.

Materials and methods: Work was initiated and coordinated by Agridea and financially supported by the Swiss Federal Office for Agriculture and the project IWMPRAISE (grant 727321). The activities were launched on the topic of problematic plants on alpine pastures. Species were prioritized and five were selected for a first series of videos. The five to ten-minutes videos always featured a farmer and an expert, who both presented for about half of the time. Implementing both, peer and expert teaching (Franz et al. 2010) was assumed to facilitate knowledge transfer to the heterogeneous community of alpine staff. Special emphasis was placed on adapting pasture management and mechanical intervention rather than the use of herbicides.

Videos were produced following a standardized procedure: (1) the available knowledge was collected and summarized. (2) Key messages were elaborated and discussed in the group of authors. (3) Potential farmers and experts to be featured were selected. (4) A more detailed screenplay was elaborated, listing the messages and contents to be presented together with ideas for possible image settings. (5) The video was usually filmed during one day. Only occasionally, a second day was required for additional scenes, especially if several seasonal aspect of the plant needed to be captured. Filming was carried out using a portable camera with external microphone and complemented by a drone for overview scenes. (6) The video was edited and the draft version was revised by the group of authors. (7) The final version was edited and speeches were transcribed for translation into French or German, depending on the original language of the video. (8) The final video was subtitled and released on YouTube. In conjunction with each video, detailed information was prepared for release on the new website. As for the videos, a standardized format was established. The primary sections were (A) occurrence and distribution, (B) situation analysis, (C) regulation measures, (D) adjustment of management, (E) mechanical intervention and (F) chemical regulation. After consultation within the author team and with additional experts, the information was published on the web.

Results: The website https://www.patura-alpina.ch was released in summer 2019 and is freely available in two languages (German and French). In April 2020, it contained information on five plant species groups, commonly perceived problematic on alpine pastures: (1) alpine dockweed (*Rumex alpinus*), (2) white hellborum (*Veratrum album*), (3) rush (*Juncus effusus* and *Juncus inflexus*), (4) alpine ragwort (*Senecio alpinum*) and (5) bracken (*Pteridium aquilinum* and *Dryopteris filix-mas*). Further videos and website contents on thistles (mainly *Cirsium* species), dwarf shrubs (*Juniperus communis* and *Rhododendron hirsutum*) and green alder (*Alnus viridis)* are planned for release. The website will be continuously updated and complemented with success stories of farmers. Information is also available in the smartphone app of Agridea. Since the release of the website, the videos were viewed more than 5500 times in total. Feedback from farmers as well as farm advisors was generally positive.

Conclusion: Communicating with farmers by means of video and web content is a contemporary means of knowledge transfer. The standardized procedure to produce educational videos and web content has proven to be cost and time efficient and may inspire similar approaches on other topics in mountain agriculture.

Daily energy expenditure for locomotion by sheep in the Pyrenean summer mountain grasslands.

Larraz V. [1], Reiné R. [1], Barrantes O.[1, 2], Fillat F.[3]

[1] Department of Agrarian and Environmental Sciences, University of Zaragoza, Zaragoza (Spain) [2] AgriFood Institute of Aragon-IA2-CITA, University of Zaragoza, Zaragoza, (Spain); [3] Pyrenean Institute of Ecology, Jaca (Spain); vlarrazg@gmail.com

Keywords: GPS, energy requirements, grazing, cost of walking.

Introduction: Energy requirements of grazing animals may dramatically increase over those of confined animals. Under some grazing circumstances, the energy cost associated with walking can have an appreciable effect on the energy requirements (Lachica, 2005). The aim of this study was to evaluate the energy expenditure for locomotion by sheep on summer mountain pastures.

Materials and methods: The experiment was conducted on the mountain grasslands of Collarada (Huesca, Spain) during the 2019 summer grazing season. Four Rasa Aragonesa ewes were randomly selected from a flock of 1000 sheep and fitted with GPS collars, which recorded positional data at 11-min intervals. QGIS software was used to get altitude points from Digital Terrain Model (DTM). Position and altitude data were used to estimate distance travelled, sheep speed and slope between successive points over time. The energy cost of walking was calculated using Brockway and Boyne equation (1980): Cost (J/kg per m) = $2.35 + 0.398G + 0.0286G^2 - 0.036S + 0.00052S^2$, where G is the gradient measured in degrees and S is speed measured in m/min. The energy expenditure for locomotion (MJ) was calculated by multiplying the energy cost of walking, the average weight of an ewe and the distance travelled. Data were processed with Excel and statistical data analyses were performed using SPSS software.

Results: Daily energy expenditure for locomotion of a 60 kg ewe was 2.83 MJ/day. This value is below the value found by Betran et al (2017) on transhumant routes (4.2MJ/day) and in range with those obtained by other authors for sheep on pasture: 1.7 MJ/day (Osuji,1974) and 2.9 MJ/day (Lambourne and Reardon, 1963). Average hourly energy expenditure for locomotion allows us to distinguish two periods of increasing and decreasing walking activity, a night resting period and a midday resting period (Fig.1).

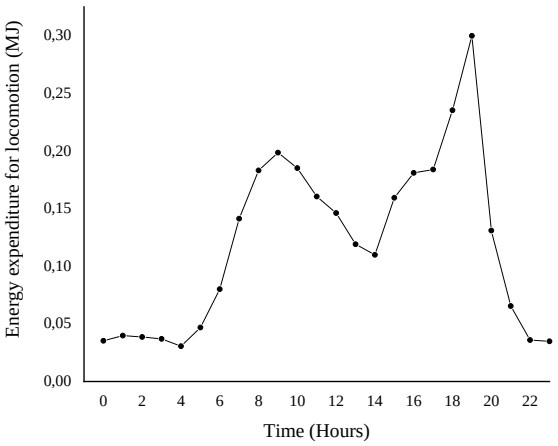


Figure 1. Evolution of average hourly energy expenditure for locomotion during the 2019 summer grazing season at Collarada grasslands.

Conclusion: Knowledge about activity and behaviour of free-ranging sheep may contribute to an efficient management of summer mountain pastures. Further studies should be done to discriminate grazing behaviour within the different periods of activity.

The "Animal Sense" warning system. Low-cost technology to prevent collisions between semi-domestic reindeer and vehicles

Hansen I.[1], Eilertsen S. M.[1], Jørgensen G. H. M.[1], Karlsson J.[2]

[1]Norwegian Institute of Bioeconomy Research, NO-1431 Ås, Norway; [2] Umeå University, Dept. of Applied Physics and Electronics, SE-90187 Umeå, Sweden; inger.hansen@nibio.no

Keywords: Arctic conditions; car accidents; electronics; preventive measures; wildlife

Introduction: Collisions between free ranging animals and vehicles have become an increasing problem, both in Nordic countries and in Europe. In Norway, more than 3000 semi-domestic reindeer were killed by trains during the last 10 years and this have led to considerable animal suffering and costs for reindeer owners. Animal population density and traffic intensity are important factors that seem to explain much of the increasing number of ungulate-vehicle accidents on both railroads and roads. . The aim of our study was to document the preventive effect and operation reliability of a new electronic warning system for reindeer in a harsh Arctic winter climate.

Materials and methods: The "Animal Sense" warning system is developed and designed at the Umeå University Embedded Systems Lab, and based on ordinary radio technology (805.15.4866 MHz). The transmitters are light and tiny, estimated battery life is 5 years, and production costs per transmitter are about 10 €. Over three consecutive winters (2018-2020), a total of 724 semi-domestic female reindeer were equipped with transmitters integrated into standard plastic collars, sending radio signals with a range of around 100 meters. A total of 41 receivers in 2018, 39 in 2019 and 35 in 2020 were mounted on top of road sticks along a 4.5 km test distance at road E6 over Saltfjellet, close to the Arctic Circle (66^0 N). These receivers were equipped with red lights that started blinking if reindeer with transmitters were nearby. The number of semi-domestic reindeer killed by vehicles within the test distance were registered and operation reliability of receivers and transmitters were recorded routinely throughout the test periods.

Results: No reindeer, with or without senders, were killed by collisions within the test distance during the experimental periods 2018-2020. However, during the same period up to 10 reindeer per year were killed in traffic accidents north and south of the test distance. Since reindeer is a very gregarious species, it may not be necessary to instrument all individuals in a flock with transmitters. This notion is supported by our results. The warning system may have a general preventive effect, as the driver will reduce speed when blinking lights have been observed. Thus, any fourth test period should include speed measurements. The project has involved a continuous upgrade of technology, software and hardware. The operation reliability of receivers increased with 50 % from 2018 to 2019 after adjustments of transmitter-receiver communication was conducted. The transmitters seem to have satisfactory battery capacity, but a sample control of 180 transmitters in February 2019 revealed that 35 % had stopped working due to the type of microcontrollers used that year. These microcontrollers were replaced and all transmitters tested worked well in 2020. The winter 2020 was characterized by very rough weather and difficult grazing conditions, and most of the reindeer had to be moved to other grazing areas by the end of January. Thus, it was not possible to document the mitigation effect of the warning system this winter.

Conclusion: The low-cost "Animal Sense" electronic warning system has a promising potential regarding preventive effect, energy efficiency and use of materials that can withstand a harsh Arctic winter climate. A fourth test is imperative for the system to obtain a status as «proven technology» and later can be released into the commercial market.

VegeT: An Easy Tool to Classify and Facilitate the Sustainable Management of Seminatural Grasslands and Dynamically Connected Vegetation of the Alps

Leoni V.[1], Giupponi L.[1, 2], Pedrali D.[1], Rodari A.[1], Giorgi A.[1, 2]

[1]Centre of Applied Studies for the Sustainable Management and Protection of Mountain Areas–CRC Ge.S.Di.Mont., University of Milan, Via Morino 8, 25048 Edolo (BS), Italy;
[2]Department of Agricultural and Environmental Sciences-Production, Landscape and Agroenergy-DiSAA, University of Milan, Via Celoria 2, 20133 Milan (MI), Italy;
valeria.leoni@unimi.it

Keywords: ecological indices; land management; mountain grasslands; mountain vegetation; spreadsheet

Introduction: Mountain grasslands represent agroecosystems that are, other than an important economic and historical-cultural heritage, biodiversity hotspots and elements that contribute to landscape enrichment. Pastures and meadows require regular and periodical management: grass-mowing, manuring, sometimes irrigation, domestic animal grazing and bush removal. In the last decades, the European Alps have been subject to abandonment by population and progressive neglection of agricultural practices and then the forest expansion in areas once occupied by mountain grasslands (meadows, pastures, and meadows-pastures). Forest expansion is a phenomenon following the timeline and the modalities of secondary plant succession: once the grasslands start to be unkempt, their plant communities are generally replaced by herbaceous plant communities (fringes) that afterward, passing the time, give way to shrublands (mantles) and, finally, to forest communities. The European Union is making efforts to protect this heritage and resource for low input farming (meadows and pastures are among the ecosystems to safeguard under Habitats Directive (92/43/EEC). To be successful, safeguarding and restoring projects need actions that require the involvement of actors with different roles and expertise. Very often the bodies managing the alpine resources turn towards experts/professionals as environmental scientists or botanists. Technical-scientific reports produced by botanists, although, have a high technical level of information but they are regrettably difficult to understand by a non-specialist in the field. The aim of the work was to develop an easy-to-use tool to facilitate the exchange of information among the different professionals in charge of studying and managing these important agroecosystems of Alps.

Materials and methods: The easy-to-use tool "VegeT" was elaborated upon the floristic-ecological analysis of the vegetation of Taleggio Valley (Insubric district of Central and Eastern Alps ecoregional section) performed applying multivariate analysis techniques and considering the different vegetation types of the mountain belt (720–1710 m a.s.l.). Floristic data of these vegetation types were collected performing 48 phytosociological relevés in accordance with the method of Braun-Blanquet. The conventional ecological indexes of Landolt (T, temperature; K, continentality; L, light intensity; F, soil moisture; R, substrate reaction; N, nutrients; H, humus; D, aeration) and mowing tolerance index (MV), were used to analyse the ecological characteristics of the different vegetation typologies. For every relevé, the average value of each index (weighted by the percentage of coverage of every single species) was calculated. Then, data were elaborated through multivariate analysis and organized in excel sheets.

Results: From the analyses, it emerged that N and MV are the main variables on which to base a classification system of alpine mountain grasslands to return useful information for management decisions. N index indicates whether the soil of the grassland considered is rich or poor in nutrients while MV allowed for a clear separation between grasslands and other vegetation typologies (shrublands and forests) and suggested where an accurate mowing and shrubs removal was requested. The classification system and the excel tool was then elaborated and calibrated based on MV and N indexes.

Conclusion: The software tool VegeT can assist land managers in the sustainable management of Alpine grasslands facilitating the interpretation of the floristic-vegetation datasets (created by botanists), as it returns outputs straightforwardly understandable and needs clear and affordable materials and methods: floristic-vegetation data provided by botanists, N and MV indexes of Landolt and Microsoft Excel®. https://www.mdpi.com/2073-445X/9/12/473/htm

Session 4: Product quality and value chains

Take home messages

from oral and poster presentations

***On-farm* factors predicting the fatty acid profile of herbage from semi-natural grasslands and derived bulk cow milk**
Renna M., Ferlay A., Lussiana C., Bany D., Graulet B., Wyss U., Ravetto Enri S., Battaglini L. M., Coppa M.
Reliable predictions of the FA profile of permanent grasslands and of the derived bulk milk can be obtained based on site altitude and grassland characteristics. Models could help farmers designing management strategies to improve the nutritional quality of the milk from their grazing herds.

Authentication of feeding specifications of Protected Designation of Origin cheese using milk mid-infrared spectroscopy
Coppa M., Martin B., Hulin S., Guillemin J., Gauzentes J.V., Pecou A., Andueza D.
The MIR on bulk milk is able to give useful indicators of cow diet composition for the authentication of PDO cheeses.

Cheese composition from cows given a tannin extract in two different grazing seasons
Menci R., Natalello A., Luciano G., Priolo A., Valenti B., Di Falco A., Rapisarda T., Caccamo M., Constant I., Niderkorn V., Coppa M.
The findings of this study suggest that dietary tannins have no detrimental effects on cheesemaking at practical doses. Resorting to tannin extracts and tanniferous forages or by-products for dairy cow's feeding could be considered all year long or even recommended during dry season.

Ways to improve the profitability of sheep farming with rare indigenous mountain sheep breeds
Ketterle N., Kollektion der Vielfalt, Zell (D)
Reducing production costs and giving wool back its true value increase the profitability of wool production from indigenous mountain sheep breeds. By buying woollen products the consumers not only support mountain sheep farming, biodiversity and landscape conservation, but also the recreation of the local textile economy. *Furthermore, the general attitude of the consumers and the knowledge changed a lot within the last 15 years. Sustainability and traceability became more and more important. A high traceability of the products generate benefits for the consumer and the sheep farmer, and saves the rare indigenous mountain sheep breeds from extinction, preserving the countryside.*

Sustainable Norwegian sheep production: fresh meat supply and niche markets

Bhatti M. A., Steinheim G., Ådnøy T., Eik L. O.

Rangeland grazing and use of local feed resources is vital for the Norwegian sheep production system to fulfil year-round fresh meat and niche market demands.

The effect of the fattening period on the fatty acid composition of grazing lambs of two genotypes

Cividini A.

How long should be the fattening period of weaned lambs on pasture, not to eliminate the positive effect of green grazing on the fatty acid composition of lamb meat?

Profitable sheep production strategies: effect of breed and grazing on farm economy

Bhatti M. A., Steinheim G., Ådnøy T., Eik L. O., Asheim L. J.

Rangeland grazing and use of local feed resources is vital for the Norwegian sheep production system to fulfil year-round fresh meat and niche market demands.

Hilly and sub-mountain agroecosystems of Italy are rich in herbaceous landraces

Giupponi L., Pedrali D., Leoni V., Rodari A., Giorgi A.

The aim of this study is to investigate the situation for Italian herbaceous landraces preserved on farms (in situ) by merging and analyzing data contained in the main databases on plant agrobiodiversity in Italy. A total of 1615 herbaceous landraces were found (versus the 416 recorded in the Agrobiodiversity National Register). Poaceae, Fabaceae, and Solanaceae together comprise 70% of all herbaceous landraces and are mostly preserved/grown in hilly and sub-mountain areas (between 150 and 800 m a.s.l.). The results of this research will be useful to enrich the Agrobiodiversity National Register and trigger actions of characterization, conservation, and promotion of these plant resources.

A system to promote a traditional raw milk product

Mazzucchi M., Partel E., Iussig G.

This work aims to illustrate the production strategy developed for "Botìro", a butter obtained from raw cream, skimmed by spontaneous creaming of raw milk. The control system application over 10 years has allowed the producers to maintain all the hygienic parameters under control or to improve them.

Animal welfare assessment in alpine dairy farms with different housing systems

Partel E., Lora I., Scalet L., Cozzi G.

The increasing awareness of consumers' towards the farm animal welfare issue has stimulated the different productive chains to certify the respect for minimum requirements on-farm. This study described the overall level of animal welfare and the main deficiencies assessed by the ClassyFarm checklist in 44 alpine dairy farms.

Mountain dairy farming systems and product qualities; what is new?

Manzocchi E.[1,2], Coppa M.[1], Delbes C.[1], Verdier-Metz I.[1], Martin B.[1]

[1]INRAE, Université Clermont Auvergne, VetAgro Sup, Joint Research units on Herbivores and Cheese, Auvergne, France; [2]ETH Zurich, Institute of Agricultural Sciences, Zurich, Switzerland; mauro.coppa@inrae.fr

Keywords: Mountain, Dairy farming systems, Milk, Cheese, Sensory, Nutritional, Microbiota

Key not summary:

Mountain areas have considerable limitations in land-use possibilities that result in an increase in the milk production and collection cost. To face the higher costs, commercial strategies have been historically adopted to increase the value of mountain dairy products (i.e., Protected Designation of Origin (PDO) specification or specific national labels for mountain productions). The success of these strategies relies on the consumers' willingness to pay and liking for mountain dairy products which are partly related to their specific quality. This synthesis describes the state of the art and relates the recent advances in the field of the study of the relations between mountain dairy farming systems and dairy product qualities.

From the nutritional point of view, several studies have highlighted a specific composition of commercial dairy products from mountain origin. They have a higher n-3 fatty acid (FA), CLA, and lower saturated FA concentrations, in comparison to lowland dairy products. Mountain milk is also richer in terpenoids and in vitamins A, E, B2 and B9 than lowland milk. Mountain forage system based on permanent grasslands is the key driver of this mountain milk specificity. When consumed by adults, mountain dairy products from pasture could reduce the contribution of dairy products to dietary nutrient intakes of deleterious saturated fatty acids (i.e. lauric, myristic and palmitic acid, from 48 to 40%) and increase the furniture of beneficial FA (linolenic acid, from 3 to 9%) and vitamin A (from 10 to 14%) in comparison to lowland dairy products from cows fed maize-based diets. In contrast, the benefits of choosing mountain products for other nutrients like minerals and water soluble vitamins is limited because the concentration of these nutrients in dairy products is more related to process than to milk composition.

From the sensory point of view, mountain raw milk and cheeses have more complex sensory features, characterized by a higher number of sensory attributes with specific and diversified herbaceous and animal notes, and stronger taste and flavour compared with lowland ones. Recent results outline that in addition to the type of herbage ingested, the herbage utilization method per se also matters. For instance, indoor green-feeding vs. grazing of the same plot results in cheeses with similar composition and texture, but flavour may differ slightly, possibly in link with raw milk microbiota composition. The high throughput sequencing approaches will help monitoring microbiota assemblage and identifying microbial sources for milk and cheese. First results outline the importance of teat skin microbiota as a secondary source of microbial diversity for cheese and show how animal feeding and management may modify teat microbiota. In this field there is a lack of comprehensive studies on pathogens' prevalence and composition of microbial communities in dairy farm environments that could help understanding the cheese flavour development and more broadly have interesting insights on animal and human health.

The recent results presented confirm the high potential of mountain products for differentiation. They also underline the pivotal importance of maintaining grassland-based farming systems in mountain areas in a context of climate change and progressive intensification that could impair the specific qualities of mountain products.

On-farm factors predicting the fatty acid profile of herbage from semi-natural grasslands and derived bulk cow milk

Renna M.[1], Ferlay A.[2], Lussiana C.[3], Bany D.[2], Graulet B.[2], Wyss U.[4], Ravetto Enri S.[3], Battaglini L. M.[3], Coppa M.[2]

[1] Department of Veterinary Science, University of Turin, 10095 Grugliasco (TO), Italy; [2] Université Clermont Auvergne, INRAE, VetAgro Sup, Saint-Genès-Champanelle, France; [3] Department of Agricultural, Forest and Food Sciences, University of Turin, 10095 Grugliasco (TO), Italy; [4] Agroscope, Posieux (FR), Switzerland; mauro.coppa@inrae.fr; manuela.renna@unito.it

Keywords: cow milk; fatty acids; herbage; prediction model.

Introduction: Individual factors able to affect fatty acids (FA) in herbage and cow milk are well known (Elgersma, 2015; Hanuš et al., 2018). However, the relative weight of these factors still has to be clearly assessed. This study evaluated the relative hierarchy of *on-farm* factors, related to site and grassland characteristics as predicting variables of the FA profile of semi-natural and highly biodiversified species-rich permanent grasslands and of the bulk milk obtained from herds grazing those areas.

Materials and methods: Data were collected from 2003 to 2016 by 3 European Research Institutions. A dataset of high variability was built up including: site altitude and climatic conditions, grassland botanical composition, herbage phenology (BBCH) and growth cycle, herbage proximate composition, herd characteristics, milk gross composition, herbage and milk fatty acid profile. General linear models were used to obtain prediction equations for the FA profile of herbage and milk using Minitab *v*. 14.1.

Results: Herbage proximate composition and phenology weighed more than site altitude and botanical composition in predicting the main FA in permanent grasslands (Table 1). Diet composition (% of fresh grass and concentrates), site altitude and grazed grassland features concurred to predict C16:0, C18:2 *c*9*t*11, C18:2 n6 and C18:3 n3 in milk. Beside diet composition, herbage phenology and site altitude fitted the selected milk FA better than herbage proximate and botanical compositions (Table 1).

Table 1. Prediction models of selected herbage (H) and milk (M) fatty acids (g/100 g of total FA; n=144).

	Equation	Fisher's F	RMSE	R^2
H - C16:0	14.17 (±0.6) + 0.144 (±0.020) × DM + 0.0250 (±0.0126) × L - 0.78 (±0.174)*	DM: 50.8; L: 3.9; GC: 20.1; E: 39.5.	1.96	0.65
H - C18:2 n6	22.00 (±1.58) – 0.00204 (±0.00033) × A + 0.055 (±0.0107) × P – 0.0468 (±0.0122) × G – 0.208 (±0.063) × CP	A: 37.9; P: 26.7; G: 14.8; CP: 10.8; E: 27.5.	2.08	0.63
H - C18:3 n3	61.97 (±3.31) – 0.156 (±0.027) × P – 0.428 (±0.074) × DM + 0.135 (±0.029) × G + 0.00322 (±0.00085) × A – 0.174 (±0.072) × NDF + 3.02 (±0.47)*	P: 34.7; DM: 33.9; G: 20.9; A: 14.3; NDF: 5.8; GC: 40.6; E: 53.3.	4.96	0.81
M - C16:0	35.27 (±1.24) – 0.0638 (±0.0115) × FG – 0.216 (±0.057) × CP – 0.00118 (±0.00033) × A	FG: 30.9; CP: 14.2; A: 12.9; E: 39.6.	1.43	0.70
M - C18:2 *c*9*t*11	0.85 (±0.16) – 0.0127 (±0.0017) × P + 0.000377 (±0.000063) × A + 0.000062 (±0.000014) × FG^2 + 0.00719 (±0.00178) × G – 0.223 (±0.035)*	P: 53.9; A: 35.9; FG^2: 20.7; G: 16.4; GC: 40.8; E: 8.9.	0.28	0.59
M - C18:2 n6	0.95 (±0.19) + 0.0176 (±0.0027) × C + 0.00643 (±0.0014) × FG – 0.0205 (±0.0070) × CP	C: 41.4; FG: 21.1; CP: 8.7; E: 20.6.	0.19	0.54
M - C18:3 n3	0.69 (±0.14) + 0.00627 (±0.00101) × FG – 0.00346 (±0.00141) × L – 0.0163 (±0.0069) × CP	FG: 38.3; L: 6.0; CP: 5.6; E: 59.6	0.17	0.74

A = altitude; C = % of concentrates in cow diet; CP = crude protein; DM = dry matter; E = lab error; FG = % of fresh grass in cow diet; G = grasses; GC = growth cycle; L = legumes; NDF = neutral detergent fibre; P = phenology. *Correction of intercept according to GC; if GC > 1st: the additive constant coefficient changes from + to – or *vice versa*.

Conclusion: Reliable predictions of the FA profile of permanent grasslands and of the derived bulk milk can be obtained based on site altitude and grassland characteristics. Models could help farmers designing management strategies to improve the nutritional quality of the milk from their grazing herds.

Authentication of feeding specifications of Protected Designation of Origin cheese using milk mid-infrared spectroscopy

Coppa M.[1], Martin B.[1], Hulin S.[2], Guillemin J.[3], Gauzentes J.V.[4], Pecou A.[5], Andueza D.[1]

[1] Université Clermont Auvergne, INRAE, VetAgro Sup, UMR 1213 Herbivores, F-63122 Saint-Genès-Champanelle, France ; [2] Pôle Fromager AOP Massif Central, 20 côte de Reyne, F-15000 Aurillac, France; [3] Cantal Conseil Elevage, 26 rue du 139ème Régiment d'Infanterie - BP 239, F-15002 Aurillac, France; [4] Agrolab's, 38 Rue de Salers F-15000 Aurillac, France; [5] CNIEL, 42 rue de Châteaudun I, F-75314 Paris, France; mauro.coppa@inrae.fr

Keywords: MIR, Milk, Authentication, Feeding, Cheese

Introduction: Authentication of farming practices through rapid analyses on products is a concern of mountain Protected Designation of Origin (PDO) cheeses, which specifications require restrictions in animal feeding. The aims of this work was to test the ability of MIR on bulk milk to authenticate the cow feeding restrictions included in the specification of two PDO cheeses of French Massif Central.

Materials and methods: A total 7607 bulk milk spectra from 1355 farms and their corresponding on farm surveys of cow diet composition were collected from April 2018 to march 2019 on the mountain area of French Massif Central. The dataset was divided into a calibration (n = 6107) and a validation sets (n = 1500), by farm, allowing to obtain two independents datasets. Discriminant analysis were used to authenticate the cow feeding restrictions of Cantal and Laguiole PDO cheese specifications

Results: Discrimination models for pasture presence, pasture ≥ 50% (Cantal PDO specifications) and pasture ≥ 57% (Laguiole PDO specifications) in cow diet showed accuracy and specificity ≥ 90%. Sensitivity and precision ≥ 85 % were also observed for the pasture proportion discrimination models, but both these parameters decreased at increasing threshold from 0 to 50 and 57% of pasture in cow diet. Accuracy ≥ 80% was observed also for pasture + hay ≥ 72%, herbage ≥ 50%, pasture + hay ≥ 25%, absence of fermented herbage, absence of maize silage and maize silage ≤ 30% in cow diet, but for several models, either sensitivity or precision were lower than the accuracy. Models built on the respect of all the criteria of the feeding restrictions of PDO cheeses specifications gives accuracy, specificity, sensitivity and precision > 90%.

Table 1. Sensitivity, specificity, precision and accuracy indexes in validation for discriminant analysis performed on milk samples to authenticate the cow feeding restrictions included in the specification of PDO Cantal and Laguiole cheeses.

PDO Cheese	Criteria[1]	Sensitivity (%)	Specificity (%)	Precision (%)	Accuracy (%)
Cantal	P presence	87.6	92.4	89	90.4
	P≥50	78.5	96.7	82.8	93.7
	C<28	88.8	34.2	73.6	71
	P+H≥25	82.5	84.7	86	83.5
	M<30	88.3	74.7	87.8	83.9
	G≥50	87.9	84.3	89.2	86.5
	Respect of all the PDO criteria	91.1	89.2	92.6	90.3
Laguiole	P≥57	66.5	97.6	81.1	93.5
	P+H≥72	44.5	97.8	80.3	89.1
	FF absence	54.4	96.1	79	87.3
	FH absence	61.1	89.7	74.3	80.3
	M absence	80	85.9	80.9	83.4
	Respect of all the PDO criteria	100	99.4	97.8	99.5

[1]C, concentrate; FF, Fermented forages; FH, fermented herbage; G, herbage (fresh and conserved); H, hay; M, maize silage; P, Pasture.

Conclusion: Discriminant MIR models on bulk milk can provide to producers and consumers useful indicators on the respect of feeding restriction of PDO cheeses specifications.

Cheese composition from cows given a tannin extract in two different grazing seasons

Menci R.[1], Natalello A.[1], Luciano G.[1], Priolo A.[1], Valenti B.[2], Di Falco A.[3], Rapisarda T.[3], Caccamo M.[3], Constant I.[4], Niderkorn V.[4], Coppa M.[5]

[1] Department Di3A, University of Catania, Catania, Italy; [2] Department DSA3, University of Perugia, Perugia, Italy; [3] Consorzio Ricerca Filiera Lattiero-Casearia (CoRFiLaC), Regione Siciliana, Ragusa, Italy; [4] INRAE, Université Clermont Auvergne, Vetagro Sup, UMRH, Saint-Genès-Champanelle, France; [5] Independent researcher at the INRAE, Université Clermont Auvergne, Vetagro Sup, UMRH, Saint-Genès-Champanelle, France; ruggero.menci@unict.it

Keywords: tannin, cheese quality, dairy cow, grazing season, Mediterranean

Introduction: Extensive farming systems are characterized by periods with different forage availability along the year, as they strictly depend on climatic conditions for pasture. This imbalance in diet has well-known implications in dairy cow performance and product quality. When green pasture is not available, the use of dry forages and concentrates may lower product quality and even lead to nutritional stress, particularly in Mediterranean and tropical areas. On the other hand, milk is richer in protein and fat and have healthier fatty acid profile during the grazing season, but green pasture may cause a soluble N surplus in the rumen, thus lowering protein use efficiency and increasing urinary N release in the soil.

Tannins are polyphenolic compounds commonly found in forages and agricultural by-products. Thanks to their antimicrobial and protein binding activities, they can improve N metabolism and fatty acid profile of ruminant products. Indeed, tannin extracts are commonly marketed for zootechnical feeding.

However, little is known about the effectiveness of dietary tannins according to pasture availability in extensive farming. Therefore, the aim of the present study was to compare for the first time the effect of dietary tannins on cow cheese quality in two different grazing seasons under Mediterranean climate.

Materials and methods: Two experiments were performed on 14 dairy cows reared in extensive system. The first experiment took place in the wet season (WS) with green pasture availability and the second one in the dry season (DS), when no fresh herbage was available. In both experiments, cows freely grazed green pasture (in WS) or dry stubbles (in DS) and diet was supplemented with pelleted concentrate and hay. In both experiments, the cows were divided into two balanced groups: a control group (CON) and a group receiving 150 g/head × d of tannin extract (TAN). After 23 d of dietary treatment, 7 kg of individual milk was collected and processed into individual *canestrato* cheeses and aged 25 d. Weight and pH were monitored during the process. Cheese was analysed for fat, protein and calcium contents, proteolysis and fatty acid profile. Data from WS and DS experiments was statistically analysed separately with an ANCOVA model of IBM SPSS For Analytics. Measurements on cheese produced before the beginning of both experimental trials were included as covariate.

Results: The supplementation dose used in this work (1% of estimated dry matter intake, DMI) did not affect cheese yield, cheese fat, protein and calcium contents or cheese proteolysis, regardless of the grazing season. In WS experiment, dietary tannin supplementation had no effect on cheese fatty acid profile. In DS experiment, TAN cheese had lower C18:1 *t*10 concentration (-23%) and *n*-6 to *n*-3 polyunsaturated fatty acids ratio (-25%), compared to CON group. These differences are likely due to the effect of tannins on fatty acid bio hydrogenation.

Conclusion: Dietary tannins at 1% of estimated DMI had no detrimental effect on cheese yield or cheese composition, regardless of the grazing season under Mediterranean climate. Tannins bioactivity on ruminal biohydrogenation seems to be enhanced during the dry season, when diet is low in protein and rich in high structural carbohydrates. Our findings suggest that resorting to tannin extracts and tanniferous forages or by-products for dairy cow's feeding could be considered all year long or even recommended during dry season, regarding cheese fatty acid profile. Further studies are needed to investigate the effects of longer supplementations or higher doses or different tannin sources.

This study is part of the european project ProYoungStock.

Ways to improve the profitability of sheep farming with rare indigenous mountain sheep breeds

Ketterle N.[1]

[1] *Kollektion der Vielfalt, Zell, Germany; nathalie.ketterle@kollektion-der-vielfalt.de*

Keywords: preserving alpine biodiversity, renewable research wool, sustainable woollen products, from sheep to shop, value chain for wool, natural coloured wool

Introduction: "Kollektion der Vielfalt" is a wool project in Germany where sheep breeders have organised themselves and collaboratively created a local brand for woollen products from rare indigenous mountain sheep breeds 15 years ago.

When we started our project, the renewable research wool was regarded as waste and it had no use at all. Shearing their sheep causes costs for sheep breeders instead of increase their income and in most cases is only done for animal welfare reasons. Instead of throwing away an eco-friendly and sustainable fibre, we found use for the wool of our indigenous mountain sheep breeds by processing natural coloured wool from rare indigenous mountain sheep breeds into sustainable and long-lasting woollen products.

Results: The main goal is the preservation of rare indigenous mountain sheep breeds by using their typical and natural coloured wool to increase the income of the breeders. In addition, we are raising the profitability of mountain sheep farming and wool production by reducing costs and enabling the achievement of higher prices for sustainable wool products.

By selling our high quality woollen products directly from "sheep to shop", the whole value chain is maxed out, increase the income of the breeders, supporting preservation of rare indigenous mountain sheep breeds and maintaining and sustaining alpine biodiversity and cultural heritage.

The project has contributed to agriculture and landscape conservation as well as to the promotion of old and endangered mountain sheep breeds and the preservation of their genetic diversity.

Instead of throwing a sustainable and renewable natural fibre away, our project supports a re-valorisation of the renewable resource wool and demonstrates ways to exploit its commercial potential.

Conclusion: Our project has increased the profitability of wool production from indigenous mountain sheep breeds by reducing production costs and giving wool back its true value and thereby increasing prices for high quality wool products. By buying our woollen products the consumers cannot only support mountain sheep farming, biodiversity and landscape conservation, the consumer can also support the recreation of the local textile economy offering an alternative to the unsustainable global textile production systems which has threatened traditional regional cloths almost to extinction and critically damaged the health of our planet.

Furthermore, the general attitude of the consumers and the knowledge changed a lot within the last 15 years. Sustainability and traceability became more and more important. Now consumers are aware of the microplastical pollution synthetical cloths are causing. Thanks to all the information we spread over the last 15 years, more and more consumers are buying and enjoying woollen products that have grown on indigenous mountain sheep breeds.

Sustainable Norwegian sheep production: fresh meat supply and niche markets

Bhatti M. A.[1, 2], Steinheim G.[1], Ådnøy T.[1], Eik L. O.[2]

[1] Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences (NMBU), Norway;
[2]International Environment and Development Studies, Noragric, NMBU, Norway;
muhammad.azher.bhatti@nmbu.no

Keywords: Spæl-sheep, Fresh meat, Niche markets, Sheep production

Introduction: *Norwegian Sheep production system:* Norway has the largest sheep population (>1 million winterfed ewes) in Scandinavia. Sheep farming is a part-time activity for most farmers.
The sheep farming system is adapted to produce most of the (slaughtered) lamb crop from natural pastures over a three- to four-month period from May to September. The concentrated slaughtering season (September – November) reduces the availability of year-round fresh meat (Statistics Norway 2017). Additionally, a large quantity of frozen meat (lamb and sheep) exerts costly pressure on storage facilities and disturbs the market balance. This leads to lower meat prices and affects the meat consumers' appeal to and consumption of lamb/sheep meat. To overcome the limited out-of-season meat supply, a better understanding of the Norwegian sheep farming system is vital for sustainable sheep meat production. Summer range grazing (90-100 days, mostly on mountain areas), winter indoor feeding, and meat market prices are the critical factors to be considered when suggesting any changes in the current practices (Asheim 1999). Our aim was to increase year-round fresh meat availability, exploring new niche meat (halal) markets (such as Muslim festivals), and increase the profitability of sheep farming (economic analysis) and the meat industry (meat sensory and consumer analysis) in Norway. This study was part of the *Fjorlam* project funded by the Regional Research Council, Rogaland Norway.

Niche-markets and consumer survey:
In Norway, Muslims are the second-largest religious group after the Christians. Eating halal meat is associated with religious belief. A better understanding of this niche market may play a significant role in increasing the sales and consumption of Norwegian sheep meat. Therefore, the aim was a better understanding of the halal meat consumers' purchasing preferences. A cross-sectional survey was conducted in Oslo using a snowball sampling technique. Without prior knowledge about the market segments, a descriptive post hoc market segmentation was performed using latent class analysis to address the heterogeneity of respondents in choice data and to develop market segmentation. The latent class approach simultaneously detects relatively homogeneous respondent segments and calculates partworths (i.e. utilities) for the segments. The latent class analysis provides the benefits of aggregate estimation while recognizing market heterogeneity. The survey results showed that a majority of the meat consumers prefer to buy from halal butchers. While 2nd generation Norwegian born consumers gave 2nd preference to purchase halal meat from national supermarket chains. Trust is an important aspect when purchasing halal meat, and the market share would increase if the national supermarket chains had a wider range of halal meat products. An integration of halal butchers and national supermarket chains may have the potential to increase the trust and consequently halal meat consumption among Norwegian Muslims.
Muslim consumers represent a niche market not yet well utilized by the Norwegian sheep industry; the demand for hogget meat, in particular, is poorly served. In Norway, the dominating sheep breeds are the modern, cross-bred Norwegian White Sheep (NWS) and the old, native Norwegian Spæl sheep (NS). Our findings of similar meat sensory quality of NS hogget compared to NS lambs indicate this breed as superior for hogget production, with an additional benefit of smaller carcasses better suited to modern small households. A successful marketing strategy of hogget for the halal market, focusing on the NS breed, could increase market prices sufficiently to make such a production system profitable. NS hogget production will use less concentrates and more pasture, making it even more attractive to general Norwegian consumers who are concerned about environmental sustainability as well as product quality.

Conclusion: Norwegian Spæl breed can be used for hogget production to fulfil the demand for fresh meat and religious festivals at any time of the year, while Norwegian White sheep farming to produce lambs rather than hogget is more profitable if ewe production life is increased to more than five years. The superior meat-eating quality of the NS hogget should be advertised as a marketing strategy to get a better market price for hogget meat. To gain market share for halal meat, the national supermarket chains in Norway need to adjust their marketing strategy to include some of the services of the traditional halal butchers.

The effect of the fattening period on the fatty acid composition of grazing lambs of two genotypes

Cividini A.[1]

[1]*University of Ljubljana, Biotechnical Faculty, Department of Animal Science, Slovenia; Angela.Cividini@bf.uni-lj.si*

Keywords: lamb, grazing, fatty acid composition, concentrate supplement

Introduction: There is a current tendency toward producing lambs raised on pasture with their dams until slaughter during spring and summertime in Slovenia. However, lambs are weaned and grazed on natural pastures while supplemented with concentrates or grains to accelerate growth. Where relief conditions of the pasture allow, *ad libitum* concentrate supplement is necessary to improve the growth rate after weaning, especially when only low-quality pasture is available. Meat from grazing lambs contains less subcutaneous fat as well as less SFA and MUFA, but more PUFA, especially α-linolenic acid (ALA) and n-3 PUFA (Scerra et al., 2007; Cividini et al., 20014) compared to grain fed lambs. Cividini et al. (2014) reported that Jezersko-Solčava (JS) pasture lamb meat was considered more favourable, from the stand point of nutrition because of the higher amounts of ALA and n-3 PUFA compared to meat of grain fed JS lambs. Therefore, when grazing lambs are supplemented with concentrates, the fatty acid composition of lamb meat can be changed, and the positive effect of green grazing on the fatty acid composition of lamb meat can be eliminated. The study aimed to investigate the effect of the fattening period, during the grazing season, of lambs of two genotypes on the fatty acid composition of the intramuscular fat of the *longissimus dorsi* (LD) muscle.
Materials and methods: A total of 32 Improved Jezersko-Solčava sheep (JSR) lambs (8 male, 8 female) and crossbreds with Texel (JSRT) (8 male, 8 female) were grazed with their dams on natural pasture until weaning, at the average age of 97 days. After weaning, all lambs grazed a grass dominated pasture and were supplemented with commercial concentrate *ad libitum* for 36, 50, and 76 days until they reached 35 kg. Lambs were slaughtered on three consecutive dates by the same procedures. *Longissimus dorsi* muscle samples were carefully dissected from the loin of each carcass, vacuum packed, and stored at -20 °C until fatty acids analysis. Fatty acid methyl esters from the meat samples were prepared using the *in situ*-esterification method of Park and Goins (1994). Statistical analysis was performed by a general linear model (GLM) procedure using SAS/STAT® Software version 9.4 (SAS Inst. Inc., 2014). The model for the fatty acid composition (y_{ijk}) considered genotype (Gi) (i=JSR, JSRT), sex (S_j) (j=male, female), and the fattening period (F_k) as fixed effects. The amount of total intramuscular fat in LD was included in the model as linear regression. Least square means were compared at the 5% probability level.
Results: The results are presented in Table 1.

Table 1. Fatty acid composition (g/100 g of total fatty acids) of *longissimus dorsi* muscle from Improved Jezersko-Solčava (JSR) lambs and their crossbreds with Texel (JSRT) from three different fattening period (LSM ± SE)

Fatty acid, g/100 g of total fatty acids	Duration of fattening period on pasture (days)			Sig.
	36	50	76	
C18:2 n-6, linoleic	8.95 ± 0,48	9.98 ± 0,36	10.13 ± 0,42	ns
C18:3 n-3, α-linolenic (ALA)	1.16^{a} ± 0,05	1.04^{a} ± 0,04	0.89^{b} ± 0,04	**
c9t11 CLA, conjugated linoleic acid	0.62^{a} ± 0,04	0.46^{b} ± 0,03	0.37^{b} ± 0,03	**
Saturated fatty acids (SFA)	41.42^{a} ± 0,47	40.10^{a} ± 0,36	38.88^{b} ± 0,41	**
Monounsaturated fatty acids (MUFA)	42.10 ± 0,55	42.20 ± 0,41	43.41 ± 0,48	ns
Polyunsaturated fatty acids (PUFA)	16.32 ± 0,71	17.45 ± 0,53	17.44 ± 0,62	ns
n-6 PUFA	12.28 ± 0,66	14.00 ± 0,50	14.46 ± 0,57	ns
n-3 PUFA	3.47^{a} ± 0,18	3.13^{ab} ± 0,13	2.77^{b} ± 0,15	*
n-6/n-3 PUFA ratio	3.5^{a} ± 0,32	4.6^{b} ± 0,23	5.4^{b} ± 0,28	**

Sig.: significance; ns; P > 0.05; *P < 0.05; **P < 0.01; ***P < 0.001; SE: standard error of mean
[a, b]: Means with a different superscript in the same row are significantly different.

Conclusion: The duration of the fattening period of weaned JSR and JSRT lambs on pasture had a significant effect on the fatty acid composition of lamb meat. The proportion of beneficial ALA, CLA, and n-3 PUFA in lamb meat decreased with an increase in the duration of the fattening period on pasture. Lambs fattened on pasture for 36 or 50 days, constitute a recommendable production system regarding the ratio of n-6/n-3 PUFA in lamb meat.

Profitable sheep production strategies: effect of breed and grazing on farm economy

Bhatti M. A.[1, 2], Steinheim G.[1], Ådnøy T.[1], Eik L. O.[2], Asheim L. J.[3]

[1] Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences (NMBU), Norway; [2] International Environment and Development Studies, Noragric, NMBU, Norway; [3] Norwegian Institute of Bioeconomy (NIBIO), Ås, Norway; muhammad.azher.bhatti@nmbu.no

Keywords: Farm economics, Sheep breeds, Grazing-based production, Less concentrate feed

Introduction: Sheep husbandry and mountainous pastures have been important for survival of man even before the introduction of agriculture in the Nordic countries, and especially so in Norway (Edmundson, 2006; Agerskov, 2007). Sheep grazing is important for maintaining landscapes and biodiversity worldwide (Milchunas & Lauenroth, 1993). In the North-Atlantic region, the economic importance of livestock grazing has decreased significantly, and sheep husbandry is today maintained by state subsidies (Hester et al., 2005). From the early 20th century, traditional sheep production practices changed, influenced by market demands, and meat has become the main product replacing wool and milk. Failure or success of Norse societies was linked with livestock management strategies (Diamond, 2011) and defining sustainable grazing regimes remains a major challenge (Thompson et al., 1995; Mysterud, 2006). Older, native breeds may be more sustainable and efficient grazers in the rugged and heterogeneous rangelands, with their agility and surviving ability, thereby maintaining the natural landscapes.

Norway has the largest sheep population and the highest mutton and lamb meat production in Scandinavia, with more than 1 million winter-fed ewes, and produces 24403 tons (annual) of lamb and mutton (Åby et al., 2014). About 55% of Norway is mountainous areas (Nersten et al., 1999), and only 3.7% of area is arable land of which 30% is used for grains and vegetable production. The rest of the arable land is only suitable for grass production (Statistics Norway, 2020).

There are two main sheep breeds in Norway: the Norwegian White Sheep (NWS) and Norwegian Spæl (NS) sheep (Figure 2). The NWS, a composite, prolific dual-purpose breed with adult ewes weighing >85 kg (Lillehammer, 2004), constitutes 70% of the recorded sheep population (Animalia, 2018). The Nordic-type, short-tailed sheep NS is the second most common breed in Norway and makes up 21.5% of the recorded population with its three sub-types: White, Coloured, and Old Norwegian type. The dual-purpose White Spæl (9.6%) is the most common. Its ewe adult body weight is around 72 kg (Lillehammer, 2004). Compared with NWS, previous studies indicate that NS stay together in larger flocks (Drabløs, 1997) and cover longer distances on the rangeland pastures (Jørgensen et al., 2016). NS chooses more woody plants in their diet than NWS (Steinheim et al., 2003; Steinheim et al., 2005), potentially making this breed more suitable for managing grazing-affected landscapes, including traditional flowering meadows and the woody plant encroachment afflicted sub-alpine zone.

Sheep farming in Norway is important for food production and for maintaining ecosystem services (Austrheim et al., 2008). The vast natural grazing resources can accommodate more than double the current sheep population (Nationen, 2012). Still, Norwegians eat less red meat, with an average per capita sheep meat consumption of only 5.4 kg (Åby et al., 2014). Norwegian sheep farms vary in flock size from very small flocks (<10 ewes) to large ones (>150 ewes); 36.7% of sheep are found in the >150 ewes flocks, while 48% of the sheep are in medium size (50-149 sheep) flocks (Statistics Norway, 2017). Sheep farming is thus mostly a part-time occupation. The aim was to check the profitability of the Norwegian sheep production system under different scenarios thereby promoting a profitable grazing-based production system in Norway. This study was part of the *Fjorlam* project funded by the Regional Research Council, Rogaland, Norway.

Economic modelling: Based on the Norwegian White sheep breed, linear optimisation was used to compare farm profitability (gross margin) of baseline practices with four different scenarios. The alternative scenarios were: delayed lambing, hogget production, 1st lambing when two years old, and ewe longevity increased to 5.3 years with first lambing at two years of age. Hogget meat market price

and availability of autumn pasture were the critical factors affecting gross margin for "hogget production" and "delayed lambing" scenarios, respectively. Better market prices for the hogget meat would make it the most profitable production system. Increasing production life for Norwegian white sheep ewes to more than 5.3 years has the potential to increase efficiency with more lamb meat produced per live weight of ewes. The calculated amount of concentrate feed used to produce one kg of meat was lower in the case of hogget production since hoggets mostly grazed and were not mated. The farm gross margin of the two main breeds (Norwegian White sheep and Norwegian Spæl sheep) were then compared. The highest gross margin was calculated for the 4th alternative scenario (ewe production life increased to 5.3 years). The very low input meat prices for the hogget led to a lower gross margin for that alternative. Comparatively, the Norwegian Spæl breed produced a higher gross margin compared with the Norwegian White sheep breed. The amount of concentrates used to produce one kilogram of meat was lower for two scenarios: hogget production and production life increased to 5.3 years.

Conclusion: For Norwegian White Sheep (NWS) economic modelling of sheep farms showed that today's prevailing production system gives the highest gross margin, except for the increase in the production life span of ewe from 3.3 to 5.3 years. The same was the case for NS, but this breed required less concentrates per kg of meat produced, making it better at producing meat on local, natural resources. The profitability of hogget production system could be increased by getting a higher price for hogget meat. The current industry practices in Norway favour lamb production from NWS, but the benefits of using the NS for hogget production, either as a substitute or complementary breed, should be investigated further, focusing on the coastal and fjord areas with longer grazing seasons and a large potential for increased utilisation of the rugged, natural pasture areas.

Hilly and sub-mountain agroecosystems of Italy are rich in herbaceous landraces

Giupponi L.[1, 2], Pedrali D.[1], Leoni V.[1], Rodari A.[1], Giorgi A.[1, 2]

[1] Centre of Applied Studies for the Sustainable Management and Protection of Mountain Areas–CRC Ge.S.Di.Mont., University of Milan, Via Morino 8, 25048 Edolo (BS), Italy; [2] Department of Agricultural and Environmental Sciences-Production, Landscape and Agroenergy-DiSAA, University of Milan, Via Celoria 2, 20133 Milan (MI), Italy; luca.giupponi@unimi.it

Keywords: agrobiodiversity; herbaceous plants; traditional cultivars; *in situ* conservation; plant genetic resources

Introduction: The safeguarding of agrobiodiversity is an extension of the concept of biodiversity conservation that refers specifically to species of agricultural interest. Many of these genetic resources have been lost over time, replaced with other more productive varieties/races or due to changing consumer tastes. Agrobiodiversity National Registers (ANR) are one of the most important instruments for agrobiodiversity monitoring and protection. However, for what concerns Italy, 12 Italian regions currently appear without any traditional plant variety and around 80% of the plants listed are trees, with less detailed data on herbaceous species. Herbaceous species require particular attention due to the high number of species/varieties and their vulnerability among the various taxa that make up agrobiodiversity and the national genebanks lists can be often supplemented with germplasm that is not part of the government genebank system and is actively managed by farmers and gardeners organized in seed savers associations or other individuals. Very often, as in the case of Italy, public open sources of data, such as inventories produced by universities and research centres, or foundations for the conservation of agrobiodiversity such as Slow Food, can provide a considerable amount of information on agrobiodiversity. The aim of this study was then to collect as much detailed and complete information as possible regarding herbaceous landraces in Italy.

Materials and methods: This target was pursued by merging and analysing the data contained in the main databases of plant cultivars (preserved on-farm, *in situ*). The database considered were: The Agrobiodiversity National Register provided by MiPAAF (Italian Ministry of Agriculture and Forestry); the first Italian inventory of *in situ*-maintained landraces (VNR catalogue) created by the University of Perugia; The eighteenth revision of Italian Traditional Agri-food Products; The list of Slow Food Presidia (Slow Food Foundation for Biodiversity); The MiPAAF SIAN (National Agricultural Information System) list of biological seeds database; Database of CRC Ge.S.Di.Mont. (Centre of Applied Studies for the Sustainable Management and Protection of Mountain Areas—University of Milan) concerning mountain plant agrobiodiversity; minor inventories and other sources available online. Data were georeferenced, organized by botanic families and Italian regions, and analysed by GIS and R.

Results: Landraces resulted concentrated in the sub-mountain areas, between 150 and 800 m a.s.l., and, coherently, the families most numerous (*Fabaceae*, *Poaceae*, and *Solanaceae*, that together comprised 70% of all herbaceous landraces) were the one cultivable in a wide altitudinal range (from sea level to over 1000 m a.s.l.) but concentrated in hilly and sub-mountain areas (150–800 m a.s.l.). This is due to the fact that these families contain plants adaptable to, and grown in, these environments, such as beans (*Phaseolus* spp.), rye (*Secale cereale*), potatoes (*Solanum tuberosum*), and barley (*Hordeum* spp.). Some areas (Apennines of Molise, Abruzzo, Campania, and Calabria, the Central Apennines of Tuscany, Umbria, and Emilia-Romagna, and Central Eastern Alps on the border between Lombardy and Trentino-Alto-Adige) were identified as "hotspots" of herbaceous landraces by the Distribution Map created by ArcGIS 10 software and kernel density method using the spatial analysis tool. This is due to specific agricultural and environmental conditions but also anthropical reasons, such as the existence of specific inventories or farmers' associations.

Conclusion: Marginal mountainous and sub-mountainous areas are to protect as agroecosystems rich in traditional herbaceous plant varieties, that could help farming systems to be more sustainable, being hardy and locally adapted (Giupponi et al. 2021, https://www.mdpi.com/1424-2818/13/2/70).

A system to promote a traditional raw milk product

Mazzucchi M.[1], Partel E.[1], Iussig G.[1]

[1] Technology Transfer Centre, Fondazione Edmund Mach, San Michele all'Adige (TN), Italy; gabriele.iussig@fmach.it

Keywords: raw milk, raw butter, milk quality, quality control system, summer pasture

Introduction: In the summertime cattle usually spend few months grazing the alpine meadows. High quality milk can be obtaind when dairy animals are brought to the summer pastures (SP). The traditional management of the alpine meadow is critically for the manteinance of biodiversity, for the protection of the territory from hydrogeological instability and for the economic and touristic value. The raw milk obtained from these extensive grazing systems is usually processed into cheese and butter directly on site but sometimes it is transported and processed to local dairies. The use of raw milk allows to add value to dairy products but it has to comply with the increasing hygiene standards imposed by the EU legislation. Producing according to these rules and remaining competitive is a great challenge, both in resources and economic terms, for small dairies with small quantities of product. This work aims to illustrate the production strategy developed for "Botìro", a butter obtained from raw cream, skimmed by spontaneous creaming of raw milk, highlighting how it has maintained its typical features while ensuring compliance with the highest sanitary standards.

Materials and methods: "Botìro" is a slow food presidium produced by "Caseificio Primiero" from milk collected in five SP (sites), beneath the Dolomite peaks of the Pale di San Martino (northern Italy). Sampling of bulk tank milk from each 5 summer meadows has been analized all season long. All the farms involved follow a mastitis control plan, that to guarantee a high standard hygiene milk quality. The cows are monitored with milk culture at least twice during lactation. A careful monitoring of somatic cell count, fat and crude protein both at farm and cows level is due. Also the total bacterial count and the presence of the major pathogens (eg: Salmonella, Listeria, coliforms bacteria, ecc.) are monitoring for all production lots. Milk hygiene is also guaranteed by monitoring the correct sanitation of the milking system and the milk cooling tank as well as the correct storage temperatures (Lactocorder®). A great value is made also for the staff training about best practices and pasture management. The control system put in place for the production of "Botìro" take in account all the parameters involved in the supply chain, starting from the valley floor upwards.In order to assess the bulk tank milk quality between six and eight samples per year have been collected from each SP from 2010 to 2019.

Results: The milk is excellent both in terms of hygienic (somatic cell count, total bacterial count and major pathogen) and nutritional quality (fat and crude protein). The somatic cell count was always lower than the hygiene standard in two sites (SP1, SP2) and only occasionally higher than it in other two (SP4, SP5) (Fig.1).

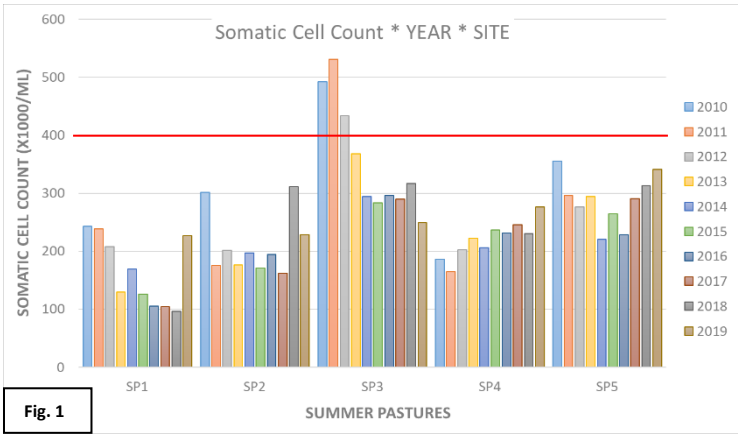


Fig. 1

A significant number of values above the limit (400.000 cells/ml) was observed only in one of the five sites (SP3). However, these refer to the first three years of observation (from 2010 to 2012).

The mean total bacterial count (TBC) of every year and pasture showed values lower than 40.000 CFU/ml (legal limit: 100.000 CFU/ml). The crude protein values were very stable among the pastures and over the years while the fat content of milk seem to be slightly more variable (min: 3,89%; max: 4,88%).

Conclusion: Milk quality control programs are usually applied at farm level but they are rarely applied at the SP level. The control system put in place for support the "Botìro" production is a good example of how a traditional product can be made in the full respect of current health and hygiene regulations. Its application over 10 years has allowed the producers to maintain all the hygienic parameters under control or to improve them. During last two years STEC analysis had been included in the health monitory program to ensure "Botìro" quality. All these factors in addition to the great taste quality allow producers to earn an adequate selling price and the customers to buy this traditional high quality product.

Animal welfare assessment in alpine dairy farms with different housing systems

Partel E.[1], Lora I.[2], Scalet L.[2], Cozzi G.[2]

[1] Technology Transfer Centre, Fondazione Edmund Mach, Via E. Mach 1, 38010, San Michele all'Adige (TN), Italy; [2] Department of Animal Medicine, Production and Health, University of Padova, Viale dell'Università 16, 35020, Legnaro (PD), Italy; erika.partel@fmach.it

Keywords: dairy cow, mountain farm, welfare checklist, tie-stall, loose housing.

Introduction: The increasing awareness of consumers' towards the farm animal welfare issue has stimulated the different productive chains to certify the respect for minimum requirements on-farm. In Italy, a new method of farm classification based on resource- and animal-based measures of animal welfare and on management indicators has been developed and is under trial for different species. This assessment scheme, called "ClassyFarm", has been recognized as the reference method by the Italian Ministry of Health, and it is currently applied optionally in the dairy sector by several cheese factories. This study described the overall level of animal welfare and the main deficiencies assessed by the ClassyFarm checklist in 44 alpine dairy farms.

Materials and methods: A cheese factory of the Province of Trento (northern Italy) commissioned to a trained veterinarian a pre-assessment of the animal welfare status of its supplying dairy farms based on the ClassyFarm checklist. The aim was of both assessing the baseline welfare situation of its associate dairy farms and training the breeders on animal welfare requirements, preparing them for future official inspections. The ClassyFarm checklist, which was developed based on the Welfare Quality® protocol, is complex and differs in some specific items for farms with tie-stall (**TS**) or loose housing (**LH**) systems. Three main areas were assessed: "management and personnel", "facilities and equipment", and "animal-based measures". The first two areas included 13 (TS) to 17 (LH) and 14 (TS) to 18 (LH) resource-based measures, respectively, whereas the third area included 12 (TS) to 10 (LH) animal-based measures. Overall, 44 farms (30 TS and 14 LH) were inspected from November 2019 to February 2020. The herd size of TS farms ranged from 3 to 40 cows (13±9; mean±SD), whereas LH farms reared 25 to 42 (32±5; mean±SD) cows. Brown Swiss and Simmental were the main breeds reared and all farms provided access to pasture during the summer period for dairy cows.

Results: Overall, management indicators showed a good level of attention by farmers towards their animals in terms of skills, number of inspections per day and interaction with animals during routine handling. Resource-based measures showed that all the farms fulfilled the minimum law requirements for animal welfare and a share of them, ranging from 25 to 70%, provided comfort benefits above the minimum threshold. Some improvements would be needed about diet formulation of TS farms (27%) and comfort and cleanliness of the resting areas in both systems (TS and LH). The main critical points regarded either the absence or the poor management of the calving pen in LH farms (57%; item not included in the checklist for TS farms), and either the lack or the poor management of a dedicated infirmary area in both systems (63% of TS farms and 50% of LH). Only a small proportion of TS farms (<25%) had some deficiencies in the housing structures for calves. However, in line with the results from resource-based measures, the outcome of the animal-based measures was very satisfactory for both types of farms, with some improvements needed only about animal cleanliness, particularly for TS farms.

Conclusion: Farms showed an overall good level of animal welfare, with some deficiencies that can be easily fulfilled. Thinking to a broad application of this welfare assessment scheme in the mountain areas, the main deficiencies are supposed to target farms with limited availability of indoor space. Because space allowance is the main constrain for alpine farms, specific solutions should be studied to overcome the need for expensive housing rearrangements or new building construction. Moreover, the results highlighted that small-scale farms would need a simplified checklist, as several managerial and resource-based items included in the assessment were found to be not sensible in farms with less than 10–15 cows.

Session 5: Management options for ecosystem services

Take home messages

from oral and poster presentations

Short-term response of permanent meadows with intermediate species richness levels to fertilisation with organic manures
Peratoner G., Zwack B., Mayr M., Figl U., Querini M., Wellstein C.
First effects of moderate fertilisation with organic manures on the vegetation of mountain meadows were detected already after the first application year. Moderately species-rich meadows showed to be more sensitive to it than moderately species-poor meadows.

Vegetation and environmental factors affect Carbon stock of Alpine pastures
Ravetto Enri S., Petrella F., Ungaro F., Zavattaro L., Mainetti A., Lombardi G., Lonati M.
Soil C stock in Alpine pastures is influenced by precipitation, pH, and particularly by grassland species composition. Pastures with higher abundances of dry grassland species stocked more Carbon in the upper soil horizons.

Relative importance of topography, climate, species composition, and phenology in affecting forage yield and quality in alpine summer pastures
Mainetti A., Ravetto Enri S., Pittarello M., Lombardi G., Lonati M.
Eco-climatic variables as water stress and phenology have a greater influence on forage quality than topography and species composition in alpine species-rich summer pastures. The abundance of broadleaf grasses and legumes can partially counterbalance the degrading effects of eco-climatic variables.

Scale matters – habitat use and selection by two sheep breeds in two contrasting Norwegian alpine environments
Jørgensen N. H., Steinheim G., Holand Ø.
Sheep habitat use and selection seem to be affected by the proportion and spatial heterogeneity of the vegetation classes.

Mediterranean mountain management with extensive livestock as strategy for enhancing ecosystem services
Nadal-Romero E., Khorchani M., Cortijos-López M., Sánchez-Navarrete P., Errea P., Lasanta T.
Land management in Mediterranean mountains, through shrub clearing in selected areas and continuous grazing, can be a good strategy to provide ecosystem services to society, contributing to the maintenance of natural resources and local development.

Effects of molasses-based blocks on Highland cattle grazing in green alder-encroached pastures

Svensk M., Mariotte P., Perotti E., Pittarello M., Nota G., Barberis D., Lonati M., Probo M.

Highland cattle showed a high potential to graze in green alder-encroached pastures, enhanced by the placement of attractive points, which further increased their impact on green alder.

Apennine pasture as potential ecosystem services source: a case study

Fatica A., Circelli L., Manzo A., Di Iorio E., Colombo C., Salimei E.

As a contribute to the socio-economic and cultural valorisation of inner areas of central-southern Italy, acknowledged in 2019 by UNESCO as Intangible Cultural Heritage, this study aims to highlight the potential ecosystem services that these areas could provide also in terms of biodiversity and environment protection.

Diurnal activity rhythm on summer pastures of two sheep breeds in two contrasting Norwegian alpine environments

Rise R., Jørgensen N. H., Steinheim G., Holand Ø.

Time of day influenced the ewes' activity pattern. The ewes have two prominent grazing activity peaks, a major peak in the afternoon, where about 80 % of the ewes are active, followed by an equivalent synchronous period of inactivity around midnight, and a somewhat smaller grazing peak at sunrise. The diurnal rhythm is similar throughout the grazing season, whereas the interaction between time of day and grazing week suggests that the diurnal activity is affected by day length.

Monitoring of mountain meadows in Slovakia

Martincová J., Vargová V., Čunderlík J., Kováčiková Z., Pollák Š., Jančová L., Britaňák N., Hanzes L.

Many semi-natural grasslands in the whole Europe are in unfavourable conservation status due to successional changes induced by the land abandonment. After political changes in 1989, rapid decline of grassland area was reported also from Slovakia, where their decrease was more than 50 % (Michalec & Jendrišáková 2006). Loss of grassland was significantly accelerated due to dramatic decline of the cattle number. The protection and restoration of species rich grasslands are important issues in current forest - agricultural policy in Europe. So for that reason, new technological procedures being search for their ecological renewal which include for example fresh- cutting („green hay"), threshed hay seeding, brush harvesting, seeding of local ecotypes, soil transfer (Kirmer a Tischew, 2006, Edwards et al., 2007, Scotton et al., 2012, Jongepierová et al., 2007, Šeffer et al., 1999).

The effect of management practices on soil nutrient status, forage yield, feeding value and plant diversity of species rich meadows in the Soča Valley region

Žnidaršič T., Verbič J., Žnidaršič Pongrac V., Dakskobler I., Šilc U., Vreš B.

On intensively managed meadows twice as much of crude protein and NEL can be produced than on extensive meadows. Forage from intensive meadows is also characterised by its higher protein and energy value and higher content of phosphorous. On the other hand, about twice as many plant species can be found on extensively managed meadows than on intensive ones.

Dry matter production of semi-natural grassland and its mineral element concentrations under cutting and mulching management in chosen Slovakian mountains

Britaňák N., Vargová V., Hanzes Ľ., Kováčiková Z.

There is a need for feeding wildlife from previously abandoned grassland which served as draft horses feed. We compared two techniques (mulching and cutting) on elements content in herbage. Nutrients content of N, P, K, and Mg were higher under cutting management. Higher Ca, and Na concentrations were detected under mulching.

Best practices for targeted policies to enhance ecosystem services in European mountains

Bernués A.[1, 2], Martín-Collado D.[1, 2], Tenza-Peral A.[1, 2]

[1] Unidad de Producción y Sanidad Animal. Centro de Investigación y Tecnología Agroalimentaria de Aragón (CITA), Zaragoza, España; [2] Instituto Agroalimentario de Aragón – IA2 (CITA-Universidad de Zaragoza), Zaragoza, España; abernues@cita-aragon.es

Keywords: sociocultural valuation, agricultural practices, policy scenarios, sustainability

Key note summary:

Agri-environmental policies in European mountains are failing to address ongoing landscape change, biodiversity decline, and societal demands for sustainability due to the lack of clear and objective targets. In this context, payments for ecosystem services (PES) arises as a promising instrument to reconcile agriculture development and nature conservation objectives, encouraging the maintenance and recovery of mountain agroecosystems. However, the value of nonmarket functions depends deeply on societal perception. How do farmers (as providers) and citizens (as main beneficiaries and consumers) value the ecosystem services delivered from mountain agroecosystems and the agricultural practices that provide them? Moreover, given the great heterogeneity of mountain agroecosystems in Europe and their traditional practices, are all ecosystem services equally important everywhere? Do common agricultural practices have the same effect on all agroecosystems?

Here, we present the results of a transdisciplinary and long-term research, based on sociocultural valuation methods, on mountain agroecosystems in the Mediterranean and Nordic regions of Europe that enables us to shed some light on these questions. We used focus groups to analyze the perception of farmers and other citizens (non-farmers) regarding the relationship between agricultural practices on mountain agroecosystems and the provision of key ecosystem services (maintenance of scenery from agricultural landscapes, conservation of biodiversity, regulation of climate change through carbon sequestration, production of local quality products, maintenance of soil fertility, and prevention of forest wildfires). We also analyzed the best agricultural practices in both Mediterranean and Nordic mountain agroecosystems to reach the targeted environmental outcomes under three plausible policy scenarios.

Our results highlight the intuitive recognition of the ecosystem services derived from mountain agroecosystems by farmers and citizens. Although farmers showed a large capacity to recognize, the complexity of ecological processes in agroecosystems, identifying more clearly the cause-and-effect relationship between their agricultural practices and the delivery of multiple ecosystem services. On the other hand, the comparison between the mountain agroecosystems in Mediterranean and Nordic regions showed that not all the ecosystem services have the same priority in all regions, nor do common agricultural practices have the same effect on ecosystems services in different agroecosystems. This suggest the need for regionalizing the research efforts and, consequently, the design of agri-environmental policies. We also identified a number of practices that are relevant for ecosystem service delivery across policy scenarios and agroecosystems. Especially, grazing and silviculture practices such as extending the grazing period, grazing in semi-natural habitats, grazing in remote and abandoned areas, adapting stocking rate to the carrying capacity, and moving flocks seasonally, stand out for their relevance in all policy scenarios. We highlight the potential of grazing and silviculture practices to deliver bundles of ecosystem services. Our research can provide sound and clear guidance on farming practices to be promoted under the current agri-environmental policies in Europe that focus on climate change mitigation and adaption, sustainable and efficient management of natural resources, and biodiversity conservation.

Short-term response of permanent meadows with intermediate species richness levels to fertilisation with organic manures

Peratoner G.[1], Zwack B.[1, 2], Mayr M.[1, 2], Figl U.[1], Querini M.[1], Wellstein C.[2]

[1] Laimburg Research Centre, Ora/Auer, Italy; [2] Free University of Bozen-Bolzano, Bolzano/Bozen, Italy; giovanni.peratoner@laimburg.it

Keywords: mountain permanent meadows, diversity, fertilisation, organic manures, stoichiometry

Introduction: Permanent meadows in the Alps are an important source of biodiversity. In general, the negative relationship between fertilisation and botanical diversity is well known (i.e. Humbert et al. 2015), but there is an ongoing debate about which organic fertilisers, and in which amount, are suitable to preserve biodiversity whilst allowing further agronomic use of meadows at the threshold between moderately species-poor and moderately species-rich meadows. A field experiment was established to investigate the effect of the initial vegetation type (meadow class), of the type of organic manure and of the level of applied nutrients on plant performance and diversity. Short-term results after the first fertiliser application are presented.

Materials and methods: A field experiment (54 plots in total) was set up in South Tyrol at three locations (Mantena/Montal, Monterota/Ratsberg, Rudiferia/Rüdeferia) from the montane to the subalpine zone as a split-plot design. The meadow class (C1: moderately species-poor/C2: moderately species-rich according to Tomasi et al. 2016) at trial start was the main plot, whilst the type of organic manure (slurry/farmyard manure/combination of farmyard manure and liquid manure) and the nutrient input level (F0 = unfertilised control/F1 = equivalent of a total N-input of 55.5 kg ha^{-1}/F2 = equivalent of a total N-input of 111 kg ha^{-1}) were randomized within the main plots. The botanical composition (cover of each species across all vegetation layers) was assessed in each plot (25 m²) prior to the first cut in the first year before applying the fertilisation treatments (mean species number $plot^{-1}$: 28.2 vs. 39.0 for C1 and C2 respectively) and in the second year after the first fertiliser application (with the last split dose of slurry and liquid manure at the highest input level having not been applied yet). Species richness, Shannon diversity, Ellenberg nitrogen indicator value, the proportion of Grime's functional types (C-S-R), the number of indicator species for extensive management and the cover of indicator species for intensive management according to Tomasi et al. (2016) were derived by the vegetation data. Moreover, leaf area index (LAI, measures with AccuPAR LP-80 ceptometer), as well as the dry matter content of N, P and K (only for F0 and F1) in the aboveground plant material of six species occurring in all plots (*Arrhenatherum elatius*, *Dactylis glomerata*, *Trisetum flavescens*, *Carum carvi*, *Taraxacum officinale*, *Trifolium repens*) were investigated prior to the first cut in the second year. The forage yield over the whole growing season was assessed as well (mean of four sampling areas of 0.25 m² each per plot). All data (difference between the first and the second observation year for all parameters obtained in both years, otherwise the value of the second year) was analysed by means of mixed models and mean comparisons by LSD.

Results: No effect of the investigated factors was detected on the changes over time concerning species richness, Shannon diversity, Ellenberg nitrogen indicator value, proportion of Grime's functional types and the proportion of grasses and forbs. Similarly, only in two plots (one of them being a control treatment) a change of the meadow class (both from C2 to C1) from one year to the next was observed. However, a stronger increase of the cover of indicator species for intensive management was detected for C2 only depending on the nutrient input level (-4.3% for F0 vs. 5.8% and 9.3% for F1 and F2 respectively), whilst no significant difference was found for C1. A similar pattern was observed for the N content: for C2, the mean content over all species was higher for F1 than for F0 (13.1 vs. 11.97 g kg^{-1} respectively), whilst no difference was found for C1 (17.22 vs. 17.34 g kg^{-1}). Altogether, these results suggest that C2 meadows are more sensitive to fertilisation than C1 in the short term. Moreover, the nutrient input level was found to affect both LAI (4.53 for F0 vs. 5.07 and 5.09 for F1 and F2 respectively) and forage yield (4.05 t ha^{-1} for F0 vs. 4.60 t ha^{-1} and 5.33 t ha^{-1} for F1 and F2 respectively), suggesting that in perspective, with increasing nutrient input level, higher yield would be achieved, but stress tolerant species may be withdrawn by competitor species. The manure type had no influence on the examined variables but on forage dry matter yield, with farmyard manure resulting in the lowest mean value (4.32 t ha^{-1}), the combination of farmyard manure and liquid manure yielding the highest one (4.65 t ha^{-1}) and slurry showing an intermediate yield (5.01 t ha^{-1}).

Conclusion: Although most indicators were not affected by the investigated factors in the short term, first fertilisation effects were detectable already after the first application year. Moderately species-rich meadows showed to be more sensitive to fertilisation in comparison to moderately species-poor meadows. Further results over a longer observation period are necessary to draw conclusions in the medium or long term.

Vegetation and environmental factors affect Carbon stock of Alpine pastures

Ravetto Enri S.[1], Petrella F.[2], Ungaro F.[3], Zavattaro L.[4], Mainetti A.[1], Lombardi G.[1], Lonati M.[1]

[1] University of Torino, Department of Agricultural, Forest and Food Sciences, Grugliasco, Italy; [2] Istituto per le Piante da Legno e l'Ambiente (IPLA), Torino, Italy; [3] CNR-IBE, Consiglio Nazionale delle Ricerche, Istituto per la BioEconomia, Sesto Fiorentino, Italy; [4] University of Torino, Department of Veterinary Sciences, Grugliasco, Italy; simone.ravettoenri@unito.it

Keywords: grassland, elevation, precipitation, slope, pH

Introduction: The role of land uses able to counteract current climate change, namely efficiency in carbon stocking, is becoming essential worldwide. Mountain pastures can provide many ecosystem services, such as provisioning services (e.g. biodiversity, forage), regulation and maintenance services (e.g. water purification, soil retention), and cultural services (e.g. nature-based recreation, eco-tourism) (Haines-Young and Potschin, 2018; Lavorel et al., 2017) as well as relevant soil C stocks (Canedoli et al., 2020). However, little is known about the variability of soil C stock in Alpine pastures according to different climatic, environmental, and vegetational features. The present study aimed at evaluating the relative importance of various abiotic and biotic drivers in affecting soil C stock in a wide sample of Alpine pastures.

Materials and methods: Between 2000 and 2007, we carried out 324 surveys encompassing a wide geographical and ecological range across the Western Italian Alps, including 54 different vegetation types. At each site, the complete botanical composition of grassland vegetation was determined through the vegetation point-quadrat method (Daget and Poissonet, 1971), along 25-m transects. At each transect, the relative abundance of every species was calculated as the proportion of the frequency of occurrence of each species. Species relative abundances were used to perform a non-metric multidimensional scaling (NMDS) to take the vegetation composition of each survey into account in further analyses. Additionally, a soil sample in the 0-30 cm layers was collected close to every vegetation transect and analysed for pH and organic C content (following the Walkley-Black procedure). Furthermore, bulk density was estimated according to the CREA-AA methods and used for the assessment of C stock (Calzolari et al., 2017). Mean annual precipitation (1977-2007 data series), elevation, slope, and southness were computed for each survey point and included, together with pH and the three main components of the NMDS, in a generalized linear model to predict C stock. Gaussian family was applied and the identity function was specified. Statistical analyses were carried out in R environment, using 'vegan' and 'glmmTMB' packages.

Results: Plant species distribution in the NMDS displayed a thermic-altitudinal positive gradient on the first axis, a biomass productivity negative gradient on the second axis, and a soil nutrient positive gradient on the third axis. Soil C stock of the investigated pastures varied between 1.9 and 234.9 t ha^{-1}, with an average value of 87.8 (standard error: 2.09) t ha^{-1}. According to glm results (Table 1), C stocks were significantly influenced by mean annual precipitation, soil pH, and the first axis of NMDS. Elevation, slope and southness showed non-significant effects as well as the second and third NMDS axes.

Conclusion: The novel results of this study highlighted the relevant importance of grassland species composition in affecting soil C stock in Alpine environment, while topographic attributes had negligible effects. More specifically, dry pastures on calcareous bedrock (which also generally host rare plants and a high species richness) stocked more Carbon in the soil. Future conservation strategies should aim to consider the role of dry grassland species in enhancing this ecosystem service. Nonetheless, more detailed research concerning the effects of pastoral management practices on C stock of Alpine pastures appears still required.

Table 1. Relative importance of explanatory variables in affecting C stocks of Alpine pastures, according to generalised linear model results. SE, standard errors; p, p values; NMDS, non-metric multidimensional scaling.

	β scores	SE	p	
Precipitation	9.994	2.515	<0.001	***
Elevation	7.619	4.206	0.070	
Slope	0.241	2.325	0.917	
Southness	0.182	2.237	0.935	
Soil pH	-8.574	2.752	0.002	**
NMDS1	-11.782	4.068	0.004	**
NMDS2	-3.611	2.897	0.213	
NMDS3	-1.991	2.218	0.369	

Relative importance of topography, climate, species composition, and phenology in affecting forage yield and quality in alpine summer pastures

Mainetti A.[1], Ravetto Enri S.[1], Pittarello M.[1], Lombardi G.[1], Lonati M.[1]

[1] *Department of Agriculture, Forest and Food Sciences (DISAFA), University of Torino, Italy; andrea.mainetti@unito.it*

Keywords: pasture, proximate composition, digestibility, forage productivity, biomass

Introduction: High quality and healthy food demands have continuously increased in Europe over the last years (Grunert 2013). Grasslands play a crucial role in providing milk, meat and other edible products in large areas around the world (Huyghe et al. 2014). The extensive long permanent grasslands hold a high plant species diversity and often support the provision of valuable forage sources (Ravetto Enri et al. 2016). Particularly, the forage produced by mountain summer pastures is generally the only feed for grazing livestock. The main issue in alpine pasture management is the optimal exploitation of the available forage resource in relation to seasonal advancement, altitude and vegetation composition. However, little is still known about forage yield of species-rich alpine pastures and related chemical composition. In this work, we aim at characterizing forage quantity and quality (i.e., digestibility and proximate composition) exploring the relationships with topographic, climatic and vegetation variables along the growing season. We focused on six grassland types in the western Italian Alps, characterized by contrasting environmental conditions and vegetation compositions.

Materials and methods: The study was carried out in an alpine valley of the Gran Paradiso National Park, in the south-western Italian Alps. We selected six grassland types within two altitudinal (lower: 2300 m a.s.l.; higher: 2750 m a.s.l.) and three fertility (oligotrophic, mesotrophic and eutrophic) levels. Each grassland type was surveyed five times (three replicates) during summer 2019 and 2020, for a total of 162 vegetation surveys. Once plant species composition was assessed, the relative percentage covers of different functional species pools (i.e., broadleaf grasses, narrow-leaved grasses, sedges and rushes, legumes, other species) were computed. A grass sample was harvested at each survey using a portable lawn-mower (cutting height 1 cm), then air-dried, weighed and analysed with near infrared reflectance spectroscopy (NIRS) technique for proximate composition and digestibility. Topographic variables (i.e., elevation, slope) were recorded in the field. Temperatures and precipitations were measured throughout the trial and combined in a synthetic eco-climatic variable (ΔPrET) calculated as the difference between the total precipitation and the potential evapotranspiration (according to the Hargreaves equation) from the day of snowmelt. Plant phenology as well was recorded according to the Lambertin scale (Lambertin 1990). Data were analysed with Generalized Linear Mixed Models to assess the relative importance of topographic (altitude, slope and southness) and climatic (ΔPrET and mean temperatures between surveying period) variables, plant phenology and functional species pool covers in explaining forage yield and quality (in terms of digestibility, crude protein, NDF, ADF, ADL, soluble sugars).

Results: Herbage quality (except for soluble carbohydrates) was negatively affected by ΔPrET, with a larger relative importance compared to the other explanatory variables (digestibility: ΔPrET $\beta = 0.18$, $p < 0.001$; Phenology $\beta = -0.11$, $p < 0.001$; sedges and rushes $\beta = -0.04$, $p < 0.01$). Plant phenology showed a remarkable role in explaining also crude protein and fibre contents (i.e., NDF, ADF, and ADL). More specifically, a decrease in crude protein and an increase in fibre fractions was observed at advanced phenophases, thus resulting in a reduced digestibility. The cover of broadleaf grasses primarily promoted biomass production, which was in turn lowered by increasing elevation and slope. On the other hand, a minor effect on forage yield was observed for increasing cover of sedges and rushes and mean temperatures, respectively (biomass: elevation $\beta = -0.58$, $p < 0.001$; broadleaf grasses $\beta = 0.42$, $p < 0.001$; slope $\beta = -0.38$, $p < 0.05$; sedges and rushes $\beta = 0.18$, $p < 0.001$; mean temperatures $\beta = 0.15$, $p < 0.01$). At increasing cover of legumes, NDF declined and digestibility increased consequently.

Conclusion: Eco-climatic variables as water stress (i.e., ΔPrET) and phenology were the main degrading factors of forage quality in the study area. Nevertheless, the abundance of high-quality forage species (i.e., broadleaf grasses and legumes) can counterbalance these negative processes. Pastoral management in the alpine environment should therefore aim to maintain and enhance these functional species pools, especially to face the ever more frequent summer droughts and heat waves.

Scale matters – habitat use and selection by two sheep breeds in two contrasting Norwegian alpine environments

Jørgensen N. H.[1], Steinheim G.[1], Holand Ø.[1]

[1] Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences (NMBU), Norway; oystein.holand@nmbu.no

Keywords: grazing, spatiotemporal scales, heterogeneity, dBBMM

Introduction: In Norway, approximately 2 million sheep are released onto outer fields for summer grazing. Indeed, during the summer months sheep are the most common large herbivores in most Norwegian mountain areas. The sheep, of which 80% are the heavy, docile Norwegian White sheep (NWS) and 13% the short-tailed, light-footed, agile and more gregarious Spælsau (SP), graze a wide range of summer grazing environments; from coastal to mountainous inland areas. However, little is known about phenotypic plasticity in ranging behavior of sheep, how different sheep breeds interact with different rangeland habitats and how they adjust their foraging behavior at different spatiotemporal scales. Research is imperative for understanding the grazing dynamic of sheep and for a sustainable grazing management adapted to the available natural and ever-changing resources. Our objective was to investigate sheep summer foraging habitat use and selection, and to explore potential breed differences in different mountainous environments at different spatiotemporal scales.
Materials and methods: We fitted 51 ewes of the Norwegian breeds, Norwegian White Sheep (NWS) and Spælsau (SP), with GPS collars in two environments in south-east Norway, one poor (Spekedalen) and one rich (Bratthøa), during the summer grazing seasons 2013-14. The collars recorded position every hour. We investigated foraging vegetation (divided into three quality classes) use and selection by the free-ranging sheep at three temporal (the whole grazing season, consecutive 5 days periods and daily mean bounding individual time hourly steps)) and three spatial (95%, 50%, and 20% utilization distribution (UD)) scales. A utilization distribution is a probability distribution giving the probability density that an animal is found at a given point in space. The dynamic Brownian bridge movement model method (dBBMM) was used to calculate the utilization distribution (UD) area. dBBMM incorporates both the temporal and the behavioral characteristics of movement paths into the estimation. Nine vegetation types were classified into four main quality classes suitable for sheep grazing, "No grazing value", "Less good", "Good", and "Very good". The classification is relative to what is available in an area. For the analyses of effect of vegetation class on vegetation use (USE) and selection (SEL) we used general linear mixed models.
Results: Habitat use was affected by vegetation class and environment, but not by breed, at all temporal and spatial scales. In Spekedalen, at all temporal scales, the use of "Less Good" vegetation decreased and "Very Good" increased with finer spatial scales, while the use of "Good" was fairly constant. In Bratthøa, at all temporal scales, the use of "Good" dominated at the coarsest spatial scale, whereas the use of "Very Good" increased and almost equaled the use of "Good", at the two finest spatial scales. Habitat selection was affected by vegetation class at all temporal scales, by environment at the two finest temporal scales but not by breed. In Spekedalen, both breeds selected for "Very Good", with increasing intensity with finer temporal scales, while "Good" and "Less Good" were in general selected against. In Bratthøa the selection for "Very Good" decreased towards neutral and the selection against "Less Good" approached neutral with finer temporal scales, while "Good" was selected weakly against at the two finest scales.
Conclusion: The sheep habitat use and selection seem to be affected by the proportion and spatial heterogeneity of the vegetation classes. Indeed, in Spekedalen sheep were able select for the scarce "Very Good" patches at all temporal scales, increasing in intensity with finer temporal scales, while sheep in the rich Bratthøa showed a neutral selection for the two best and most abundant vegetation classes at finer temporal scales. Surprisingly, no breed specific effects were found. Our findings highlight the importance of the scarce "Very Good" patches, at fine scales, in poor Spekedalen. Indeed, this high quality and productive class is probably more important for nutrient extraction and acquisition than the use indicates.

Mediterranean mountain management with extensive livestock as strategy for enhancing ecosystem services

Nadal-Romero E.[1], Khorchani M.[1], Cortijos-López M.[1], Sánchez-Navarrete P.[1], Errea P.[1], Lasanta T.[1]

[1] Instituto Pirenaico de Ecología (IPE-CSIC), Zaragoza (Spain); estelanr@ipe.csic.es

Keywords: shrubland clearing, landscape structure, forest fires, water resources, carbon sequestration

Introduction: European Mediterranean mountains suffered throughout the 20th century, depopulation and abandonment of traditional activities: decrease in livestock censuses, massive abandonment of agriculture and under-exploitation of the forests. As a consequence, there is an intense process of natural revegetation (colonization by shrubs and forests) and afforestation with conifers in some mountain sectors. The massive revegetation of the territory has negative effects on some ecosystem services such as: (i) the homogenization of the landscape and loss of diversity, (ii) the increase in forest fires, (iii) the decrease in water resources, and (iv) changes in soil properties, soil quality and soil organic carbon (SOC). Our hypothesis is that the elimination of shrubs in selected areas (mainly abandoned areas) and the subsequent use with extensive livestock creates a mosaic landscape, which has benefits on ecosystem services. The objective is to provide results on the effects of shrub clearing and livestock grazing on the landscape structure, the evolution of forest fires, water resources and SOC.

Materials and methods: The Leza valley (Iberian System, La Rioja) and Borau valley (Central Pyrenees) were selected as study areas. The detailed methodology can be checked in published studies (Khorchani et al., 2020; Lasanta et al., 2018, 2020). In order, to understand the changes in the structure of the landscape and in the risk of forest fires, land uses and land covers (LULC) were mapped before and after shrub clearing in the Leza valley. Landscape ecology indices were applied and LULCs were classified based on their combustibility. The effect on water resources was studied in the Arnás experimental catchment (Borau valley), applying the RHESSys ecohydrological model, estimating what shrub clearing would mean in the water volume. The SOC dynamics was analysed from the collection of soil samples (up to 40 cm depth) in six LULCs (derived from land abandonment) and the subsequent physical and chemical soil laboratory analysis.

Results: Shrub clearing and the subsequent use of livestock originate a more fragmented and heterogeneous landscape, which contributes to improving biodiversity. On the other hand, it reduces the risk of forest fires, since the combustibility decreases from flammable loads of 10-15 t ha^{-1} to 1-2 t ha^{-1}, after land management. For this reason, 331 ha were burned in the Leza valley between 1983 and 1985, while only 16.8 ha since 1986 (first year of shrub clearing promoted by the Regional Government) until 2020. Furthermore, the theoretical clearing of 15.7% of the shrubs in the Arnás catchment would increase the runoff values by 16% in the first year, while it would reduce the evapotranspiration between 2.6% and 8.7%, considering a temperature increase of 2 ºC. Finally, the results of soil analyses show that mature pastures present higher SOC, both in the upper and lower layers, than the rest of LULCs, suggesting that shrub clearing and grazing may constitute a good land management strategy for SOC and a management option to mitigate climate change.

Conclusion: Land management in Mediterranean mountains, through shrub clearing in selected areas and continuous grazing, can be a good strategy to provide ecosystem services to society, contributing to the maintenance of natural resources and local development.

Acknowledgments: This research was supported by the Spanish ESPAS (CGL2015-65569-R) and MANMOUNT (PID2019-105983RB-100/AEI/10.13039/501100011033) projects funded by the MINECO-FEDER and MICINN-FEDER.

Effects of molasses-based blocks on Highland cattle grazing in green alder-encroached pastures

Svensk M.[1], Mariotte P.[1], Perotti E.[1], Pittarello M.[2], Nota G.[2], Barberis D.[2], Lonati M.[2], Probo M.[1]

[1] Agroscope, Grazing Systems, Route de Duillier 50, 1260 Nyon, Switzerland; [2] University of Torino, Department of Agricultural, Forest and Food Sciences, Largo Braccini 2, 10095 Grugliasco, Italy;
mia.svensk@agroscope.admin.ch

Key words: attractive points, GPS tracking, robust livestock, spatial distribution, sub-alpine grassland

Introduction: Over the last decades, European mountain areas have been subjected to a decrease of agro-pastoral activities, leading to landscape modifications with reforestation processes over former pastures. Green alder (*Alnus viridis*) is a pioneer species that has expanded due to land abandonment, leading to several negative agro-environmental impacts, such as a reduction in biodiversity and an increase in nitrate leaching. Robust livestock breeds able to digest green alder leaves, such as Highland cattle, could be used to reduce green alder expansion. The objectives of this study were to assess i) the spatial distribution of Highland cattle in green alder-encroached pastures, ii) the ability of attractive points to increase the exploitation of encroached areas by livestock, and iii) the short-term impacts on vegetation.

Materials and methods: During the summers of 2019 and 2020, two Highland cattle herds were placed in three paddocks along a green alder encroachment gradient in the Swiss and Italian Alps. Six to ten cows in each herd were equipped with GPS collars. In 2019, 58 botanical surveys were carried out before grazing to assess plant community composition, pastoral value (Pittarello et al., 2018) and ecological indicator values of the vegetation of each paddock. Cattle spatial distribution was studied throughout the season to assess the relationship with topographic and vegetation characteristics. During the summer of 2020, attractive points (molasses-based blocks) were added in highly green alder-encroached areas of each paddock to attract the herds. Botanical surveys were carried out before and after grazing along 10-m transects around both molasses-based blocks and paired control areas to assess the role of attractive points in increasing grazing pressure on green alder-encroached vegetation. Moreover, livestock exploitation of 50-m buffer areas around attractive and control points was assessed in 2020 and then compared to 2019.

Results: In 2019, Highland cattle were able to move to the most unfavorable areas of the paddocks, as they were able to graze on green alder-encroached areas, as well as on the steepest slopes and far from water sources. In 2020, Highland cattle grazed significantly more within 50 meters around attractive points than in control areas (+83% on average, $p<0.001$) and compared to 2019 (+222%, $p<0.001$). Herbaceous cover around attractive points strongly decreased after grazing (-77%, $p<0.001$) compared to control areas (-39%, $p<0.001$), which resulted in increased bare soil. Simultaneously, green alder leaves were also more consumed (+23%, $p<0.001$) and branches more damaged by cattle up to 10 meters around attractive than control points due to livestock movements and scratching.

Conclusion: Altogether, our findings demonstrate the ability of Highland cattle to graze in harsh environmental conditions and to exploit green alder-encroached pastures. Furthermore, the presence of attractive points was efficient in attracting cattle toward highly encroached patches, where they successfully grazed and damaged green alders. Light could thus reach new bare soil gaps, allowing the germination of typical pasture species seeds translocated by livestock. Such results highlight the high potential of this management regime to reduce green alder encroachment in the long-term.

Apennine pasture as potential ecosystem services source: a case study

Fatica A.[1], Circelli L.[1], Manzo A.[1], Di Iorio E.[1], Colombo C.[1], Salimei E.[1]*

[1] Dipartimento Agricoltura, Ambiente, Alimenti, Università degli Studi del Molise, 86100 Campobasso, Italy; a.fatica@studenti.unimol.it

Key words: Ecosystem Services, Mountain, Biodiversity, Pasture, Soil

Introduction: Among the multiple ecosystem services (ES) providing to meet the growing perception of human needs (Li et al., 2020), landscape is particularly involved, and mountain lands of Central-southern Italy are under pressure as fundamental resources and opportunity for several aspects of social, economic, and cultural activities. Clean water, food, and raw materials used by people for all needs account the multiple benefits that environment provide to the humans in terms of ES (MEA, 2005; FAO, 2016). In this context, grasslands and livestock play a crucial role as ES, also referring to the function of carbon sink, to the animal and plant diversity, to the heritage knowledge sources, and to the recovery of marginalised lands. The protection of biodiversity implies several ES (Teixeira et al., 2021), aiming to preserve both animals and their environment considered crucial for a sustainable use of landscape (Fatica et al., 2019; Miraglia et al., 2020), limiting at the same time environmental impacts, such as soil erosion which increasingly affects Apennine areas (Rosskopf et al., 2020). The aim of this study is to investigate the potential ecosystem services that a grazing area of central-southern Italy could provide, analysing soil characteristics, and plant and animal diversity.

Materials and methods: Present study was developed in an inner area of Molise region (Frosolone municipality - 41°36′ N 14°27′ E, Italy) involved in the ancient transhumance practice acknowledged by UNESCO as Intangible Cultural Heritage (UNESCO, 2019). As a contribute to the ES provided by this area located at an altitude ranging between 1250 and 1350 m a.s.l. and characterized by continental cold-humid climate, pasture (300 ha) has been studied considering its biological functions, i.e., soil characteristics and biodiversity, and their evolution compared to data from 1990 (Di Rocco et al., 1992). During a two-year grazing period (May-July), several transepts (0.5 m^2) representative of three sampling sites of pasture (named SM, CF, AQ) underwent biomass production evaluation and phytosociological investigation. Qualitative assessment of vegetation cover of sampling sites was carried out through orthophoto comparisons (QGIS ver. 3.10.2). Soil profiles of each site were sampled and classified according to USDA Soil Taxonomy (Soil Survey Staff, 2010). Grazing animal data were collected from the official recordings of Frosolone municipality for the period 2012-2020.

Results: Despite a relevant decrease in grazing species consistency, pasture areas showed localized overgrazing phenomena and a turf quality decline. Degradation phenomena negatively affected also soil conservation and landscape. Vegetation consisted in about 15 species where *Gramineae* family was the most represented in the studied areas, while *Compositae* and *Legume* families were found in CF more abundant than in SM and AQ. Due to the high variability of the turf, ranging between 1.5 cm and 40 cm, the average dry matter (DM) biomass production ranged from a minimum value of 1.87 t DM/ha in 2019 and a maximum value of 4.26 t DM/ha in 2020. Orthophoto comparison highlighted an increase of vegetal density due to progressive decrease of grassland and forest use. Soil profiles, with maximum depth around 70 cm, were characterized by low calcium carbonate content resulting in an acid and weakly-acid reaction in top and in subsoil respectively, slow permeability and high-water holding capacity, and siliceous skeleton in depth. On the peak of mountain, superficial and little undeveloped profiles were found. Soils were classified as Haplumbrets (SM and CF sites) and Hapludalfs (AQ site). Furthermore, some fire horizons were found in SM and CF areas. It is worth noting that during last nine-years period, the grazing population (about 2500 heads per year) has varied on this area showing a deep decrease of goats, horses, and donkeys.

Conclusion: This multidisciplinary work involved soil, vegetation, and animals, within a rural area characterized by strong agricultural, pastoral, tourist, cultural and eno-gastronomic roots. Results suggested interventions focused to improve the potential ecosystem services linked to this UNESCO area. By improving the agricultural services (i.e., livestock and food production, pollination, invasive species control), pasture of Molise Region could expand the ecosystem services to crucial issues, such as hydrologic regulation, erosion and land degradation reduction, carbon storage and climate regulation, cultural and non-material benefits, within the frame of biodiversity preservation and sustainable rural development.

Diurnal activity rhythm on summer pastures of two sheep breeds in two contrasting Norwegian alpine environments

Rise R.[1], Jørgensen N. H.[1], Steinheim G.[1], Holand Ø.[1]

[1] Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences (NMBU), Norway; oystein.holand@nmbu.no

Keywords: Diurnal rhythm, synchrony, sheep breed, mountain pastures

Introduction: Early warning is essential to efficiently reduce the relatively high losses of sheep on alpine fields, and thus improve the economy and animal welfare in the industry. Efforts are being made to developed robust GPS-based warning systems. This requires knowledge about the sheep's normal behavior, including their diurnal activity. Sheep's diurnal rhythm alternates between foraging and resting, including ruminating and sleeping. Intrinsic factors, i.e. hormonal and physiological processes, and extrinsic factors, i.e. day length, environmental conditions, weather, predator pressure and human activity, may affect the pattern.

Materials and methods: Activity data from 51 GPS-collared ewes were collected throughout the grazing seasons of 2013 and 2014. The GPS collars recorded movements in the horizontal and vertical plane every hour. Based on calibration tests animals were defined as inactive or active. This enabled us to study 1) the ewes' diurnal activity pattern, 2) if the pattern changes through the grazing season. In addition, we studied 3) if there is a difference between two contrasting environments (a poor vs a rich pasture), 4) If breed differences (Norwegian White Sheep (NWS) and Spælsau (SP)) affect the diurnal behavioral pattern and 5) if there is an interaction between pasture quality and breed in the activity pattern. We developed a linear model, assessing variation in activity through the day and grazing season for the two breeds and two study areas.

Results: Time of day influenced the activity. The ewes have two prominent grazing activity peaks, a major peak in the afternoon, where about 80 % of the ewes are active, followed by an equally synchronous period of inactivity around midnight, and a somewhat smaller grazing peak at sunrise. Between the early morning and afternoon grazing peaks the activity varied; ewes alternated between foraging and resting / ruminating. Interaction between time of day and week of grazing season on the activity pattern was found. There was also a tendency of breed effect. SP grazed somewhat more than NWS, and their grazing peaks were more consistent throughout the season. We found no effect of pasture quality, nor any interaction between breed and pasture quality.

Conclusion: It is well documented that sheep have a grazing peak in the morning as well as in the evening. The peak in grazing in the afternoon may be due to a higher nutrition content in the pasture at this time, as well as the lower temperature towards evening. The diurnal rhythm is similar throughout the grazing season, whereas the interaction between time of day and grazing week suggests that the diurnal activity is affected by daylength. The breed differences in activity is most likely due to that NWS is less active than SP, but also that SP is more gregarious and hence utilize larger home ranges as compared to NWS.

Monitoring of mountain meadows in Slovakia

Martincová J., Vargová V., Čunderlík J., Kováčiková Z., Pollák Š., Jančová L., Britaňák N., Hanzes Ľ.

National Agricultural and Food Centre, Grassland and Mountain Agriculture Research Institute (GMARI), Slovakia; janka.martincova@nppc.sk

Keywords: Carpathian mountain grassland, cutting and mulching management, monitoring

Introduction: Many semi-natural grasslands in the Europe are in unfavourable conservation status due to successional changes induced by the land abandonment. After political changes in 1989, rapid decline of area grassland under utilization was reported also from Slovakia. Abandonment of grassland was accelerated due to dramatic decline in livestock number, mainly in the mountains. As a result mulching techniques was adopted, which preserve grassland as a vegetation cover. But, approximately two decades of such management there were detected negative impact on species diverstiy (declines) and accumulation of nutrients in soils.

The aim of the article is to evaluate the semi-grassland conditions in selected Slovakian mountains, where we will compare cutting management (haymaking) with other non-utilized measures (mulching).

Materials and methods: In 2019, an initial botanical monitoring of grasslands was carried out at 110 selected localities in the Western Carpathians: Low Tatras National Park (48 localities), National Park Great Fatra (12), National Park Slovenský raj (6), The Slanské vrchy Hills (17), and Čergov Mountains (27). The sites were located at an altitude between 420 and 1459 m a.s.l.

Based on monitoring grassland were classified into phytocoenological units. In the same time (from mid-June to mid-July), herbage was sampled to detect aboveground production and its quality. Soils were sampled in the springtime to detect soil pH and mineral elements concentrations.

Results: The soils of the mountains have had an acidic soil reaction spanning from pH 3.13 to 6,49. During the phytocoenological survey in 2019, there were recorded several types of grasslands. The most widespread types of vegetation included the hay meadows of the *Arrhenatherion* alliance (43 stands = 39%) and the *Polygono-Trisetion* alliance (34 stands = 31%), as well as the oligotrophic and mesic meadows of *Violion caninae* alliance (two stands only = 2%). The hygrophilous meadows of the *Calthion* alliance was represented only in small fragments (10 stands and 9%). Missing 19 percent of number of areas were abandoned arable land left to succession (ex-forest nursery), and or as temporary wood dumps because of activities in forest industry and ruderal communities. In terms of management, the meadows of the Low Tatras and the Great Fatra, 70% of the evaluated grasslands was utilized by mowing, 23% by mulching techniques, and 7% not managed. On the contrary, in the other mountains: Slovenský raj, The Slanské vrchy Hills and Čergov Mountains mulching was predominant technique of management (86%) and only a small part by mowing (14%).

Mowing, contrary to long-term mulching, supported plant species diversity. However, higher mineral element contents in soils and aboveground dry matter under mulch management (especially N and K) were detected. The abandonment of any practice has led to significant changes in the species composition of grasslands. Competitive grasses and ruderal herbs were overgrown abandoned stands. And compared to mulched and mowed grasslands; they had higher values of nutrient content (N, P, and K) in the grassland biomass.

Conclusion: The results often represent insufficient management (mainly under mulching and areas left on succession) in terms of biodiversity and mineral content (in soil and aboveground dry matter biomass, too). Areas with haymaking are examples of good conditions of grassland from biodiversity, and both soil and aboveground biomass mineral contents, point of view.

Acknowledgments: This work is supported by the Cross-border Cooperation Program Interreg V-A Poland - Slovakia 2014 – 2020 and co-financed by the European Union from the European Regional Development Fund under the project "Together for the conservation and restoration of biodiversity of Carpathian mountain ecosystems". The sole responsibility for the content of this publication lies with the authors and cannot be shared with the official opinion of the European Union.

The effect of management practices on soil nutrient status, forage yield, feeding value and plant diversity of species rich meadows in the Soča Valley region

Žnidaršič T.[1], Verbič J.[1], Žnidaršič Pongrac V.[1], Dakskobler I.[2], Šilc U.[2], Vreš B.[2]

[1] Agricultural Institute of Slovenia, Ljubljana, Slovenia; [2] Scientific Research Centre of the Slovenian Academy of Sciences and Arts, Jovan Hadži Institute of Biology, Novi trg 2, 1000 Ljubljana, Slovenia; (SI) - Corresponding author: tomaz.znidarsic@kis.si

Keywords: species rich meadows, K and P soil content, dry matter yield, feeding value, plant species number

Introduction: Slovenia is one of the countries with the highest proportion of permanent grasslands in Europe. A considerable part of it is covered by species rich grasslands which are important due to its high aesthetic and natural value. This type of grasslands is endangered by the intensification of farming as well as by the land use abandonment. The aim of the present work was to quantify the effect of farming intensity on some traits important for the competitiveness of agriculture as well as for the conservation of biodiversity. The research was performed under farm conditions without prejudice to normal farming practices.
Materials and methods: Experimental work was performed in 2018 on 16 farms in the Soča Valley region. Based on the information obtained from farmers two experimental plots were selected on each farm, one on the intensive meadow (INT) and one on the extensive one (EXT). INT meadows were typically harvested 3.6 times and fertilized with 19 m^3 of manure per year. EXT meadows were typically harvested 2.3 times per year. Six EXT plots were located on unfertilized meadows while the fertilization of the remaining plots was rather extensive (typically 4.8 m^3 of manure per year). Dimensions of the experimental plots were 5×5 m (25m^2). Phytocoenological survey was performed before the first cut according to the modified standard Central-European method (Braun-Blanquet, 1964; van der Maarel, 2005). Determination of forage dry matter (DM) yield for each individual harvest was done within the same plot on the surface of 6.8 m^2. Forage composition and gas volume produced during the incubation of sample with rumen liquor were determined by the means of near infrared reflectance spectroscopy (NIRS). Net energy for lactation (NEL) was calculated on the basis of chemical composition and gas volume data. Concentrations of potassium (K) in forage samples were determined by atomic absorption spectrometry and concentrations of phosphorus (P) by UV/VIS spectrometry. Soil samples were taken to a depth of 10 cm. Plant available phosphorus (P_2O_5) and potassium (K_2O) in the soil were determined following the modified acetate-lactate extraction.
Results: On the average the content of plant available P_2O_5 and K_2O was slightly higher on INT than on EXT (7.66 vs. 4.86 mg P_2O_5 and 22.0 vs. 16.5 mg K_2O per 100 g soil, NS). In comparison to EXT, the average DM yield on INT was higher (8159 vs. 4684 kg per hectare, $P<0.001$) and the same trend was also observed for: crude protein (144 vs. 116 g kg^{-1} DM, $P<0.001$), NEL (5.27 vs. 4.85 MJ kg^{-1} DM, $P<0.001$), P (2,82 vs. 1.80 g kg^{-1} DM, $P< 0.001$) and K content (23.2 vs. 16.5 g kg^{-1} DM, $P<0.001$). Crude protein and NEL yields were also higher on INT than on EXT (1178 vs. 567 kg and 43.0 vs. 23.0 GJ per hectare, $P< 0.001$). The correlations between soil and forage phosphorus and potassium contents were very poor ($R^2 < 0.25$). The correlations between plant available nutrients in the soil and forage DM yields were even weaker ($R^2 < 0.10$). Unexpectedly, forage DM yields on plots with very low, but similar, soil levels of plant available P_2O_5 (about 5 mg per 100 g soil) ranged from about 2 to 12 tons per hectare. Phosphorus content in forage was proved to be a better indicator of DM yield compared to soil plant available P_2O_5 ($R^2 = 0.50$). The average number of plant species was significantly ($P < 0.05$) lower on INT (28.5) compared to EXT plots (46.3). The average number of endangered (red list) plant species was also on INT considerably lower than on EXT (0.06 vs. 1.0), however, the difference was not significant ($P > 0.05$). Based on the results of regression analyses it can be estimated that the increase of DM yield of 1 ton per hectare results in a decrease of 3 plant species on average. While 40-50 plant species can be expected on extremely extensive meadows (yield 2 t of DM per hectare and year), only about 25 plant species can be found on the intensively managed ones (yield 10 t of DM per hectare and year).
Conclusion: We can conclude that agricultural and nature conservation requirements can hardly be fulfilled simultaneously. Roughly, it can be estimated that on intensively managed meadows twice as much of crude protein and NEL can be produced than on extensive meadows. Forage from intensive meadows is also characterised by its higher protein and energy value and higher phosphorus content On the other hand, about twice as many plant species can be found on extensively managed meadows than on intensive ones.

Dry matter production of semi-natural grassland and its mineral element concentrations under cutting and mulching management in chosen Slovakian mountains

Britaňák N., Vargová V., Hanzes Ľ., Kováčiková Z.

National Agricultural and Food Centre – Grassland and Mountain Agriculture Research Institute, Banská Bystrica, Slovakia; norbert.britanak@nppc.sk, vladimira.vargova@nppc.sk, lubomir.hanzes@nppc.sk, zuzana.kovacikova@nppc.sk

Keywords: mountain grassland, nutrients, dry matter

Introduction: An origin and existence of semi-natural grasslands in a temperate zone, where Slovakia belongs, are an azonal biome. Majority of semi-natural grasslands are located in mountainous area of Slovakia. Due to historical development in steep mountains the grasslands were utilized as feed for draft horses used in the forestry. From mid-20th century, because of technological revolution such type of grasslands were abandoned as horses were completely replaced by machines. Logically, succession has begun. To stop tree encroachment into abandoned grassland a mulching technique was used from the beginning of 21st century. Mulching was performed once a year at the peak of biomass production. During mulching, the herbage is crushed and left on the area of grassland. This is example of largest forestry company, Lesy SR. As draft horses have declined dramatically but, opposite wildlife (wild boar, deer, etc.) has maximum numbers over a century, now. An accompanying problem, mainly in winter period, is a migration of these animals into agricultural fields in neighbouring basins. Therefore, the subject of project is to preserve semi-natural grasslands and using its dry matter production for winter-feeding of wildlife in chosen (Carpathian) mountains. In this article we present comparison of two utilization techniques (mulching vs. cutting) of grasslands and its impacts on dry matter production and elements content.

Materials and methods: Three study areas were selected: Low Tatra Mountains, Slovak Paradise, and Slanské Vrchy Mountains. 32 semi-natural grassland were equally managed by mowing (16 sites = 10 Low Tatra Mts., 6 Slovak Paradise, and 2 Slanské Vrchy Mts.) and mulching (16 sites = 4 Low Tatra Mts., 12 Slanské Vrchy Mts.). Both techniques were carried out at the end of June and early July. To assess mineral elements content in herbage and dry matter production samples of 1 m^2 were taken. These grassland were monitored in 2019 Results obtained were compared with a long-term experiment (LTE), the setup of which includes both mowing and mulching once a year. Research was conducted in the areas of the state owned enterprise, Lesy SR.

Results: Dry matter production did not differ between cutting management and mulching (unpaired *t*-test: 0.84, df=30, P=0.4). Production of mown semi-natural grasslands were slightly lower (1.50 $t.ha^{-1}$) than mulched (1.68 $t.ha^{-1}$). Concentrations of following elements were higher under management of cutting: N, P, K, Mg. The opposite was true for amounts of Na and Ca in herbage. Statistical significance was detected only for P (cutting 2.84 $g.kg^{-1}$ vs. 2.27 $g.kg^{-1}$, unpaired *t*-test: 2.05, df=30, P=0.049) and marginal significance for Na (cutting 0.28 $g.kg^{-1}$ vs. 0.31 $g.kg^{-1}$, unpaired *t*-test: 2.03, df=30, P=0.051).

Comparison between results of LTE and cutting management only revealed differences as follows: concentrations of these elements were higher in LTE – Ca and Mg (unpaired t-test-5.09, df=17, P<0.0001), as well as dry matter production (LTE 1.79 t.ha-1 vs. monitored grasslands 1.50 $t.ha^{-1}$). The other (N, P, K and Na (unpaired *t*-test-3.06, df=17, P=0.0071) dominated in monitored semi-natural grasslands.

LTE dominated in dry matter production (LTE 2.98 $t.ha^{-1}$ vs. 1.68 $t.ha^{-1}$, unpaired *t*-test 3.98, df=17, P=0.001) and divalent cations (Ca and Mg (unpaired *t*-test=6.69, df=17, P<0.0001)). Other element concentration in aboveground production was higher in monitored grassland (N and P) and with statistical significance detected for monovalent cations K (unpaired *t*-test 3.43, df=17, P=0.0032) and Na (unpaired *t*-test 2.70, df=17, P=0.0152).

Conclusion: Feed production – haymaking – from semi-natural grassland for wildlife is appropriate management, which provides lesser dry matter production than mulched grassland across monitored Slovakian mountains. Results from long-term experiment suggest dry matter production will strongly decline in the future. Therefore, mulching cannot be unilaterally excluded. Nevertheless, we recommend cutting alternated with mulching techniques approximately once per six years. Similarly, mineral fertilizers would be beneficial to applicate to mitigate some imbalances in feeds with frequency once per six years, as well. In addition, mineral supplements of Na are necessary to saturate requirements of wildlife.

Acknowledgments: This work is supported by the Cross-border Cooperation Program Interreg V-A Poland - Slovakia 2014 – 2020 and co-financed by the European Union from the European Regional Development Fund under the project "Together for the conservation and restoration of biodiversity of Carpathian mountain ecosystems". The sole responsibility for the content of this publication lies with the authors and cannot be shared with the official opinion of the European Union.



Author index