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The role of livestock grazing in karst grassland improvement

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Abstract

The aim of the work is to develop sustainable karst grassland utilisation. Results of previous research indicate, that livestock grazing can have positive impact on biodiversity of the region and well-kept appearance of the landscape. Limestone and dolomite rocks form karstic character of land, which is expressed through floristic pattern. Grazing livestock greatly affect the composition of pasture plant communities. With proper grazing management animals always cause a pasture to be a more complex mixture of plants than it otherwise would be. This is because animals graze selectively and in patches, and the effects vary in time and space. They do collect the nutrients from wider area and return them more concentrated to the soil. This has great influence on site fertility and vitality of the ecosystem. All these have effect on sward development, which will contain a wide variety of plants adapted enough to survive their different local conditions. The key indicator of a land's stability and productivity is a succession. It is the process of change and development in entire communities; soil, microorganisms, animals and plant life. To understand the nature of the forces that influence individual plants within a karst pasture sward, we need to consider what happens in the sward from the plant's point of view. For to maintain karst grassland and prevents it from bush encroachment the grazing of livestock it is of vital importance.

Keywords**:** karst, land use, grassland, grazing, succession, soils

Introduction

The Slovenian Karst Plateau is a distinctive region of the Slovenian Primorje. Its limestone composition and karstic character cause geomorphological, hydrographical as well as floristic and vegetational, soil, agricultural, and settlement pattern. The karstic ecosystem is very vulnerable and great care needs to be applied when its resources have to be manipulated (Lobnik, 2000). Long period of utilisation of karst grassland, mainly for hay making (hand cut), has caused substantial losses of some major nutrients throughout the territory. The awareness that the old system of land use is no longer possible due to the lack of suitable manpower and in view of environmental circumstances, has led to a strategy for sustainability of the area by sheep, goat and cattle farming in order to preserve the variability of vegetation and the cultural image of the landscape. To maintain karst grassland and prevent it from bush encroachment, the grazing of livestock is of vital importance.

Materials and methods

Soil

The soil formed in Karst is the most important pedosequence in Slovenia, regarding the mountain or the high mountain karst as well as the lowland, valley karst with many spatial

subsystems. Geological age defines stratigraphic position and lithological base influence the inclination, soil use and appearance of a hydrographic network. There is a significant difference in the land use on soils developed on limestone and dolomite, the difference is bigger if rocks are accompanied by crumbling, brittle and low permeable rocks (marl, schists and grits) (Stritar, 1991). Their appearance considerably changes the ratio between forest and grassland land as well as water availability. The annual precipitation is about 1500 mm, it is more abounded in the mountain region, but water quickly percolates through karstlike hollowed underground.

Rendzina soil type can mostly be found on hill tops and steep slopes. On heavy rocky and sinkholed relief the woody vegetation appears on limestone. By texture, the soil on limestone is clay. The soil on dolomite has larger capacity for moisture acceptance than on limestone. Rendzina has a high level of saturation with basic cations. On gentle slopes, mostly in dolomite, the land is suitable to be use for pastures and meadows.

Vegetation

Botanical composition and productivity of a pasture sward reflects its soil. Quality of a soil depends on the life within it. In trying to improve pasture productivity, we do concentrate on ways that favour development of soil life. Grazing animals with their dung and urine have profound effect on activity of soil microorganisms. Pasture soils contain some of the highest root concentrations of all crops. And there are 20 to 50 times more bacteria and fungi in soil near plant roots (rhizosphere) than in soil away from roots. The pasture soil is more than a growing medium; it is, teeming with life. It is world of darkness, of caverns, tunnels and crevices, inhibited by a bizarre assortment of living creatures. In the rhizosphere, chemical soil properties and microorganisms are affected by living plant roots, and vice versa.

Microorganisms in the rhizosphere influence plants in many, usually desirable ways, and we try to make a good use of this advantage for karst soil. Life would not be possible without the symbiosis between legumes and rhizobia bacteria. In this symbiosis, the legume plant determines whether or not it will be nodulated by rhizobia. The plant releases certain organic materials from its roots, which develop a rhizosphere that is favourable to rhizobia. Shading and defoliation can greatly affect the rate and amount of nitrogen fixation in nodules. Every time legumes are grazed, their nodules may fall off and decompose. Under favourable light conditions, rhizobia reinfect legumes and nitrogen fixation begins again.

Pasture soil contain three to four times more earthworms than tilled soils. Their activity makes very important contribution to aeration and movement of soils, and also makes some elements more available for plant growth. Returning animal excrement to the soil increases the number and individual weights of earthworms present in soil. Legumes such as white clover seem to have an especially beneficial relationship with earthworms. They feed on dead legume residue, and legumes gain from the improved soil fertility due to earthworm excrement.

Probably because they are out of sight, hardly anyone considers the root systems of plants when managing pastures. But, just as plant tops are affected by selective grazing of variable intensity, roots are also influenced. Since water and nutrients are taken up by roots, and nitrogen is fixed in the roots, any beneficial or adverse effect on roots is important for pasture productivity. The rhizomes and stolons of some pasture plants give them a competitive

advantage, especially in resisting treading by grazing livestock. Weeds frequently flourish when growth of desirable plants is depressed by adverse conditions or poor grazing management. When desirable plants are grazed in preference to weeds, root systems of the desirable plants become restricted, and weeds gain competitive advantage. The proportion of plant tops to roots increases if soil nutrients are present in adequate amounts, because the plants don't need to develop such an extensive root systems to find and take up the nutrients.

In a normal situation, grasses produce energy in leaves and store this in their roots. When a grass is grazed, the leaves of new shoots are very small. They use more energy than they can produce and as a result will use energy from roots. In this stage energy is the limiting factor and the growth of grasses is very slow. At the certain height the new leaves will produce more energy than they use. The remaining energy will be stored again in the roots. For good persistence of pasture plants in karst grassland it is very important that they can reach this stage of growth after every grazing. The grass has an optimal growth cycle of 30 – 90 days, while some herbs and shrubs have an optimal cycle of 4 – 5 years.

A lot of different plant species can be found within the indigenous karst sward (Kaligarič, 1997). Unfortunately, most of the grasses are of low quality (*Brachypodium* sp., *Stipa* sp., *Koeleria pyramidata* agg., *Luzula campestris* L.). Within the native sward only *Dactylis glomerata* L. and *Arrhenatherum elatius* L. can be found among good grasses. Composition of legumes is slightly better. However, it is not so important for the quality of pasture because their proportion in the sward is very low (1-3%). The low proportion of legumes is, unfortunately, a characteristic of our karst swards and almost never exceeds 6% (Kotnik and Vidrih, 1994). Among 90 different species of herbs 41 of them are medicinal plants used in phytotherapy, 11 are poisonous, 15 of them can be used in human alimentation and only 23 species of herbs have no known effects.

To understand the nature of the forces that influence individual plants within a karst pasture sward, we need to consider what happens in the sward from the plant's point of view. Through observations and measurements we should find which individual plants can gain an advantage over their neighbouring plants. If we know how plants experience their local environment, we might be able to influence that experience to manage karst grassland for higher stability and productivity.

Process of succession on karst grassland

The key indicator of a land stability and productivity is a succession. The succession means the following. It is the process of change and development in entire communities; soil, microorganisms, animals and plant life. Succession means the way different kind of plants and animals follow each other when something happens to the land. By law of nature, succession always tries to go forward as far as the climate and soil will allow. However, succession can also go backwards. This has happened in places where grass and other herbage plants have disappeared from where they used to grow. Overgrazing (over-use) and overresting (non-use) usually causes succession to go backwards down to same steps.

Backwards succession is the invasion of bushes like hazel shrub on karst grassland. Theoretically, this would mean a higher succession. However, in the environment of Slovenian karst it is the opposite process. When the woody plants flourish in declining grassland they do take more water from deeper soil layers, they need more water for

transpiration, their foliage intercepts more rain. Less water is than available for the growth of grasses, clovers and herbs. The environment is becoming drier and drier, self-filtering ability of the running water is decreasing and so is the natural water supply of the region. However this process will turn other way if forest fire does destroy woody plants vegetation.

Competition in sward

In karst environment, seldom all-necessary growth factors are adequate to meet the needs of all plants within a sward. As soon as the immediate supply of a single factor becomes less than the combined needs of the plants for that factor, competition begins. It occurs for nutrients, light and water. From the results of the repeated soil analyses it can be concluded that phosphorus should be applied every year and not every 3 years with a three times larger amount because the supply of available phosphorus in soil is actually higher if we use it every year (Vidrih, 1995).

Most of the things that plants compete for exist as a pool, which the individual plants draw from. When a pool of a certain growth factor is limited, the successful competitor is the plant that draws on the limited factor most rapidly from the pool, continues to draw on it when the supply is low, or is able to draw on it when other plants can't. The competing plant species can be described by two words: amount and rate. These advantages include greater carbohydrate storage in seeds and roots, more rapid and complete germination, earlier growth start in spring, faster growth of tops and roots, taller and more branching stems, deeper and more spreading roots, more tillers, more flowers, and larger leaves.

Woody plants

The woody plants are becoming an integral component of many European grasslands. The abandonment of grassland that is very common in mountain and especially in the karst region, due to the emigration of rural people to the urban centres, leds to the invasion of woody plants. If for no other reason the grazing will be of greater importance in the future for to protect forests from the fire. Grazing is already part of the management technique aimed at creating and maintaining fuel-breaks to limit the development of big fires (Etienne, 1996). Conserning preservation of some very rear and sensitive species occuring today in the Dinaric karst area it is clear that they will disappear in the forest. The desire of nature conservationists and landscape managers is for a target type of vegetation (*Carici-Cantaureetum rupestris*), but such vegetation is very difficult to preserve as it depends on livestock grazing. The greatest diversity of plants was recorded on the thinned shrubland grazed rotationally by sheep and goats (Batič et al., 1999).

In past the woody plants have been considered as a nuisance in grassland because they interfered with the goal of maximum production. This attitude has changed recently and projects are being carried out in Europe on the role of woody plants in livestock production systems (Spatz and Papachristou, 1999). Woody species and especially fodder shrubs can play a strategic role in complementing grasslands and other feed resources in the Mediterranean environment (Talamucci et al., 1996). It is well documented that woody species are an important fodder to animals in marginal areas. They retain leaves during the dry period with relatively high nutritive value, especially in crude protein and minerals, even when they have matured (Gaborčik, et al., 1999). They are particularly suitable for nutrient-poor soils because they have the ability to draw minerals from deep in the soil.

There is a need to develop a system that will capture and store carbon efficiently while allowing an offtake of protein. The phosphorus is required in soil to have efficient nitrogen-fixing systems. The woody plants can explot that phosphorus in deeper soil horizons, and re-cycle it back to the surface. Production of understorey herbaceous material falls with increase in crown density. Further removing the old herbaceous growth by grazing or cutting every year during the growing season will reduce herbage production but improve its quality, by favouring legumes and other low growing species suitable for animal consumption (Platis *et al.*, 1996). The beneficial effects of shelter on animals can partly compensate for this effect. The reduction of temperature by shade contributes to better animal reproduction and higher feed conversion by reducing energy expenditure.

Legume oversowing

According to experience the quality of karst pastures depends on the amount of legumes within a grass sward (Vidrih, 1988). Oversowing and sod seeding is the only practical method of introducing clover seeds into clover-deficient karst pastures. Seeding establishment from oversowing is usually poor, often with fewer than 10% of seeds sown (Charlton and Giddens, 1983). There are a few reasons for the inefficiency of oversowing and sod seeding that showed up in our experiments: unsuitable weather conditions (drought, strong wind) and insufficient level of P and pH value of the soil. Possibility of different allelopathic effects are the principal reason, as we considered, the low level of sward exploration; the competition of indigenous plants for light, space, nutrients, etc. is namely so strong that it prevents the progress of young clover plants. White clover, though of as the most commonly oversown legume on hill country may not always be the most suitable species for different situations. For high altitudes, dry conditions and low pH level, Vidrih & Vidrih (2004) ascertained that *Lotus pedunculatus* and *Trifolium ambiguum* were more appropriate and gave two times higher yields than white clover.

Managing for forward succession

A higher succession means more stability on the karst grassland. Furthermore, when succession moves forwards, the plants and animals on the land make better use of the available water, minerals and the energy from the sun. To say it the other way around: to increase the production from karst grassland, optimal use must be made from available resources like water, minerals and sunlight, which means moving towards in succession. The management intensive grazing (MIG) is defined as »any management which permanently increases both stability and productivity of karst grassland resources«.

Discusion

Grazing livestock greatly effects the composition of a pasture plant community. With proper grazing management, animals always cause a pasture to be a more complex mixture of plants than it otherwise would be. This is because animals graze selectively and in patches, and the effects vary in time and space. Animals also drop their manure and urine in patches, which affects some plants more than others. All of these things result in a sward containing a wide variety of plants adapted enough to survive their different local conditions. It is quite logical that throughout the process of evolution the pasture plants and animals have adapted to each other and that grazing is not harmful to those plants.

To understand better of the consequences of the past grazing management, first the consequences for individual grasses must be studied and then followed by the consequences for the grassland as a whole. Perennial plants found in the region are adapted to periodic lack of water, and greater carbohydrate storage in roots gives some advantages in the case of frequent grazing. The growing points of grasses are close to the ground so that they are not easily damaged. It is clear that grazing is not harmful for grassland plants if we understand and consider the growth cycle of those plants that we would like to have in karst grassland. This is quite logical since grasses and animals have adapted to each other throughout the process of evolution.

With no management or free grazing two situations can appear which are harmful for the persistence of quality plants in karst grassland. Free grazing leaves it to the animal choice what it wants to graze and where it wants to graze. An animal, which can select what it can graze, will always go for the most palatable plants, leaving the less palatable species. This leads to overgrazing of the more palatable plants and overrest of the less palatable plants. Since young grass shoots are also more palatable, animals will go for the grasses, which have recently been grazed, contributing to more overgrazing. On the other hand, coarse old stems will be left, which again increases overrest of the specific grass.

Overgrazing and overrest

Overgrazing is related to the time that plants are exposed to grazing and not to the number of animals grazing. Any grazing of leaves that regrows from root energy, rather than solar energy can be defined as overgrazing. Too frequent grazing of the karst grassland and to low plant residual without adequate recovery periods results in reduced pasture productivity. This is because the amount of roots that a plant can maintain decreases when they are overgrazed. In the situation of overgrazing, the grass does not get a chance to restore energy to the roots. If each time the newly grown grass shoots are grazed, grass has to sacrifice energy from roots to grow new shoots again. In situation, the roots mass will slowly decrease and finally the plant will die. Overgrazing generally occurs under continuous grazing or free range grazing.

The first signs of overgrazing are the creeping growth of grasses, which normally have a very upright growth. The flowering stems of these grasses are very small compared to the grass growth under a bush where they are protected from grazing. Since the root mass of overgrazed grasses is decreasing, they can easily be pulled out from soil. Their protecting role against soil erosion is decreasing with any subsequent grazing. Finally we can find dead tufts of grasses on the pasture and certain species, which can only be found under bushes or in the cracks of rocks.

In the situation of overrest, dead standing grass is shading out new shoots. These new shoots do not get enough sunlight so that they cannot function optimally and restore energy of the roots. Again and again the grass will try to survive by growing new shoots sacrificing stored energy from the roots. Finally the same will happen as with over-used plants. The root mass will decrease and slowly the grass will start to die from the centre of the plant. The first signs of overrest are old seed heads standing on a tuft of grass. The grass does not look healthy and green leaves grow only weakly around the outside. The grass starts dying from the centre of the plant and the dead material can easily be pulled out.

Conclusion

Native karst pastures produce comparatively little due to low fertility and deficiency of soil moisture during summer. Very low content of legumes can be even further depleted if the animals are herded by day and returned to folds at night. Higher and more even distributed utilisation of herbage is an important objective of pasture management on karst region. This could be best achieved by permanent fencing and subdivision of grazing land. In most circumstances, intake will be limited during late summer by nutritional factors. As the proportion of dead material in herbage increases, intake is reduced as grazing animals avoid dead herbage. Application of phosphorus fertiliser on karst pastures is a very important factor that influences the relationship between pasture allowance and post-grazing herbage biomass. Pastures with higher clover content should be used to ensure target animal lifeweight gain.

The extensification – lack of any management that should take place on abandoned karst grasslands by some proponents, often leads to an undesirable succesion of vegetation. The retention of desirable species in shrublands, both for their ecological function and their contribution to animal nutrition, depend on an understanding of the interactions between several factors. Important among these are foraging behaviour, grazing intensity and grazing frequency. Shrubland management requires a high amount of flexibility and sensitivity based on a well-founded knowledge of various interrelationships between vegetation, climate, soil and animals. For proper grazing management scheme on shrublands there is a need for much higher level of knowledge and experiences and this cannot be classified (named) as extensification. It has to be manage much more intensive in comparision with lowland pasture where higher inputs (fertilization, conservation) can be justified (applied) economically.

Researchers and advisory workers are often impatient because of slow adaptation of advances that have been obtained in management intensive grazing. They have hard time persuading farmers to adapt low-input and low-cost systems that needs higher level of knowledge for livestock producer. We all should recognize that pasture isn't for everyone. The good grazier respects the ultimate supremacy of nature. He seek ways to channel natural forces to his benefit instead of attempting to control or dominate nature. There is still so much research and promotional for capital-intensive confinement livestock operations as the only way to make money. But the cost of the inputs is rising much fester than the value of the milk and meat. It is impossible to make a living for family with just a few animals – but that would be just as true or more so in confinement as on grass. For the grazer the pasture is not just making a living but rather contributing to the healthy, environmentally sound nutrition of own family, friends, and local community, or employing livestock for manuring the land, accelerating nutrient cycling, controling the weeds and woody plants.

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