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Vegetational and Root-Ecological Investigations on Forest Pasturing and Pure Pasturing Areas of the Northern Tyrolean Limestone Alps

By

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Key words: Forest pasture, pure pasture, herbacious plants, spatial distribution of root growth, root mass.

Summary

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Forest grazing is a subject of hundreds of years old grazing allotments. Today, many experts consider forest pasturing one of the causes of soil destabilization.

The investigation of the surface and subterranean parts of the herb layer permits the elaboration of important characteristic values regarding the influence of grazing on the development of forest stands and on the stability of soils.

35 grazed and ungrazed forest pasture and pure pasture areas were mapped and investigated within permanent sample plots. They were located in an area near the present timber line. There were sample plots which, by fencing, had been excluded from pasturing use for different periods of time. This enabled us to study the question of changes in the vegetation and in root-ecological parameters after an interruption of the use as forest pasture.

Eight out of the 118 species responded markedly to the fact that grazing was no longer applied. The root-ecological investigations clearly show, that climatic conditions have a stronger influence on the root mass than pasturing, that the greatest total length of fine roots was calculated for the grazed plots. The formation of root hairs is suited to prove the effect of grazing in respect of the compaction of the soil.

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Introduction

Protection forests on carbonate sites are more heavily affected than average forests (AMT DER TIROLER LANDESREGIERUNG 1989, 1991, KREHAN & TOMICZEK 1992), which may be due to a site-related lack of nutrients, to biotic stresses or to damage caused by pollution input.

According to the Austrian Forest Monitoring System 22,3238 ha of forests (5.95 % of the total forested area or 27.63 % of the protection forests with commercial yield) are affected by forest pasturing. Such damage is found in all classes of ownership (private, industrial and state-owned forests). In the Tyrol, 67,722 ha of forested land were determined as being affected by grazing; almost half of them (32,868 ha) are protection forests with commercial yield (AGRARISCHES INFORMATIONSZENTRUM 1990). Altogether, 93,084 ha of the forested land are subject to grazing allotments in Tyrol.

A beneficial coexistence of forests and pastures is possible only near the natural timber line or in predominantly natural subalpine spruce, larch or cembran pine forests where the distance between the individual trees is much bigger than it is at lower altitudes (LICHTENEGGER 1985). The Schulterberg investigation area is an example of such an open subalpine spruce forest. To allow careful utilization as forest pasture, more detailed information about the effects of grazing is required.

Today, many experts consider forest pasturing one of the causes of soil destabilization. As no details are known about the influence of grazing on the subterranean part of the vegetation cover and the associated soil-biological processes, not only traditional investigations, but also, and in particular, surveys of the root development are required. The connections of the root competition between species of the herb layer and the tree layer (including seedlings and juvenile plants) requires therefore the quantification of the root masses and the soil-biological processes. Such quantification is effected by the exposure of entire, or parts of, root systems or by the taking of samples with the help of soil cores.

The investigation of the surface and subterranean parts of the herb layer permits the elaboration of important characteristic values regarding the influence of grazing on the development of tree stands and on the stability of soils. The data so obtained also serve as the basis of the study of changes and are used for a monitoring, as the continuous repetition of surveys allows conclusions about the succession. Comparative observations of species heights can be used to indicate changes of temporary soil conditions. The scope of assessment has been extended by the additional classification of the subterranean plant organs in respect of root mass, spatial distribution of root growth and root length. These root-ecological parameters are of special importance in respect of erosion and soil stabilization.

In recent decades numerous results of investigations about the influence of pasturing on most different soil parameters have been published. They refer to pure pastures or to forest pastures and consider predominantly or exclusively the aboveground parts of the plants; notably in the case of forest pastures investigations of the subterranean parts are almost completely missing. As to pure pastures, investigations about the lengths of sprouts and leaves in proportion to root lengths are available (ZAUPER 1991). They were carried out right beside the Schulterberg investigation area. On the uppermost plot, which is most similar to the Schulterberg sites, the lengths of leaves and sprouts were for 28 % of the species greater than those of the roots; for 72 % the lengths were equal. In the present paper also the formation of erosion scarps will be discussed. According to NEUWINGER 1982 deep landslides are favoured by cattle terraces. However, CZELL 1972 and BUNZA 1982 pointed out that increased soil compaction and the formation of water retention horizons caused by cattle terraces depend predominantly on the intensity of the damage. Also ZAMBANINI 1992 concluded that only overpasturing would cause damage. SCHWEIGHOFER 1989, too, observed a markedly increased run-off velocity of the rainwater and, as a result, a much reduced water holding capacity of the soil, on only one intensively grazed plot. Root investigations can help to determine which degree of pasturing causes such damage.

Since the works of TROLL 1944 it has been generally known that especially in the mountains some solifluction takes place, which is accelerated through particularly marked changes of temperature and through more frequent and heavier precipitation. Cattle terraces add to these effects so that for instance the bumps caused by solifluction turn into terraces. The formation of such terraces is favoured by the unbalanced growth of plants on slopes due to the unilateral incidence of heat and light. Particularly impressing examples are the terraced lawns of the *Seslerio-Semperviretum* community (KUTSCHERA 1979). Also the development of erosion scarps is first of all due to solifluction. To avoid erosion scarps, mountain farmers pierce endangered spots of the grass-covered land during or after strong precipitation in order to facilitate the runoff of the soil water and so to avoid the undermining of the grass cover.

The object of the present investigations at the Schulterberg was to elaborate characteristic vegetational values which, with special consideration of the root development, permit the evaluation of the consequences of grazing. As a first step, this involved the investigation of the vegetation cover through identification of the herbaceous plants and root-ecological investigations on grazed and ungrazed areas.

Material and Methods

Location and utilization of the sample plots

The investigated areas are located in the Achenkirch project area on the Schulterberg, near the present timber line. They are slightly sloping to the south. The forest stands are thinly stocked and of a high average age. They are typical examples of overmature, thinned out protection forests of the subalpine level of the Northern Tyrolean Limestone Alps and, in addition, have been subject to hundreds of years old grazing allotments.

The investigations were carried out on 35 small sample plots of about $1m^2$ each, which were partly used for grazing. Those small sample plots were assigned to three main sample areas 1, 2 and 3 (Figure 1).

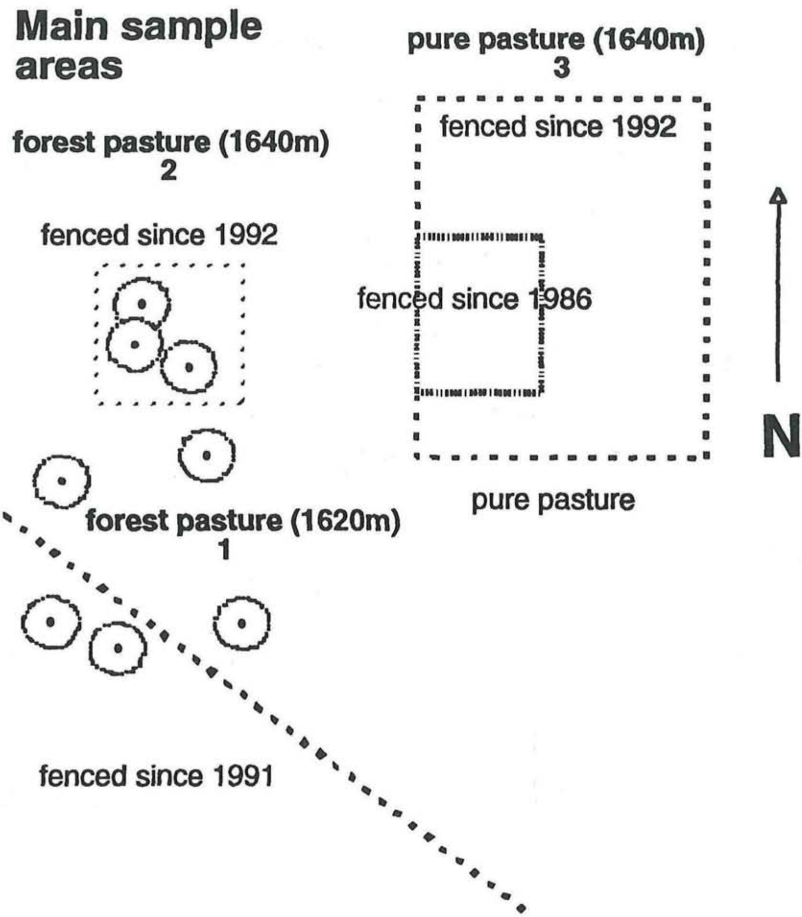
Each main sample area was approximately 1000 m^2 large; half of each main area was fenced in. Two of the main sample areas were located in the forest pasturing area, one in the pure pasture area.

The entire Schulterberg sample area is characterized by a small pattern of depressions and hillocks. It corresponds to the typical, periglacial relief and soil formation described by TROLL 1944, from the specialized literature (BRAUN-BLANQUET 1964, GRABHERR & MUCINA 1993, OZENDA 1988) we know that, depending on the respective relief form, vegetational parameters vary significantly. The area is therefore particularly suited for differentiated vegetational surveying. Using a similar mountain pasture area as an example, the influence of the different topographic elements on the micro-climatic conditions is described (LICHTENEGGER 1979).

Moreover, detailed site descriptions (ENGLISCH 1992) as well as descriptions of the soil and of the forest vegetation (ENGLISCH & STARLINGER 1995) are available for many of the plots.

Vegetational surveys

On the 35 permanent sample plots, which showed both depressions and hillocks, the vegetation was surveyed according to the "Abundanz-Dominanz Skala" by BRAUN-BLANQUET 1964. The scientific names correspond to those given in the "Exkursionsflora von Österreich" (ADLER & al. 1994); for the plant-sociological classification mainly the terminologies by OBERDORFER 1990 or GRABHERR & MUCINA 1993 and MUCINA & al. 1993 were used. The vegetational surveys were carried out once a year during the summer months.



Sample area	Sample areas (m a.s.l.)		Number of sample plots
1	Forest pasture (1620 m)	Ungrazed forest pasture:	3
		Forest pasture:	4
2	Forest pasture (1640 m)	Ungrazed forest pasture:	5
		Forest pasture:	6
3	Pure pasture (1640 m)	Fenced since 1986:	6
		Fenced since 1992:	5
		Pure pasture:	6

Fig. 1. Description of the sample areas.

Root-ecological investigations

Sampling: For the soil cores, a drill with a diameter of 7 cm and a length of 10 cm was used. Most of the samples were taken from depression sites, as sampling was not possible in the case of coarse stones.

Determination of the root mass: From the soil cores, the roots were separated from the earth with the help of a root washing machine as described by SMUCKER & al. 1982 and MURER 1987. The subterranean, washed out plant substance was divided into belowground sprout substance and roots; the roots were sorted according to their diameters (< 0.2 mm, 0.2 - 2 mm, and > 2.0 mm), dried at 70 °C for 12 hours, and weighed. By projection, the obtained values of the dried matter were converted into dt/ha (1 dt = 0.1 t). For the assessment of the rooting, the fine roots (diameter < 0.2 mm) and the roots of medium thickness (diameter between 0.2 and 2.0 mm) were considered.

Roots with diameters > 2 mm are mainly tree roots, they are not considered in the following text.

Determination of the root length: After having been dried and sorted according to diameters, the roots were moistened again and spread on a raster in order to determine their length. The length was calculated according to the formula of NEWMAN 1966:

$$R = \pi NA/2H$$

(R= root length, H = total length of the intersection lines, N = number of the intersection points between the intersection lines and the root pieces, A = area over which the root sections are spread).

Anatomical root examinations: As the composition of the species found near the soil core is known, one can tell the families and sometimes even the species of the individual root pieces with the help of the cross sections. The root atlas by KUTSCHERA & LICHTENEGGER 1982 and KUTSCHERA & SOBOTIK 1992 contains a draft key to the identification of roots. For these investigations also the roots which have already been dried can be used. The roots are for a short time put into boiling water and then sectioned.

Results

The detailed results of the investigations are given in SOBOTIK & POPPELBAUM 1995.

Vegetational surveys

The vegetation of the entire sample area forms a mosaic of species belonging to various associations and orders, such as *Poion alpinae, Polygono-Trisetion, Caricion ferrugineae, Nardion, Seslerietalia, Adenostyletalia*, and, on forest pasture sites, different forms of *Piceion* and *Fagetalia*. One should also note that the stands are very similar both to the *Crepido-Festucetum commutatae* (LÜDI 48) and to the *Caricetum ferrugineae* (LÜDI 21). The *Caricion ferrugineae* of the Bavarian-Tyrolean part of the Northern Alps, described in WÖRZ 1993, resembled the investigated stands mainly through the occurrence of *Astrantia bavarica* and *Aposeris foetida*.

The small-scale pattern of depressions and hillocks which is characteristic of the Schulterberg where the sample plots are located, causes great differences in the vegetation stands. On pure pastures the differences were more marked than between forest pasture sites. In the pure pasturing area characteristic local species of both depression and hillock sites were *Festuca nigrescens*, *Carlina acaulis*, and *Plantago alpina (Plantago alpina - Festuca nigrescens*, community). They are therefore characteristic of the entire pure pasturing area. *Plantago alpina* reaches its easternmost limit in that part of the Northern Limestone Alps. For depression sites, the occurrence of *Aposeris foetida*, *Deschampsia cespitosa* and, with less persistence, *Phleum commutatum*, was characteristic.

Typical of the hillocks of that area was the occurence of *Festuca rupicaprina* and *Alchemilla alpigena* as well as of *Thymus praecox*. The stands found in depressions and on hillocks are part of the *Plantago alpina - Festuca nigrescens* community, with the stands in depressions belonging to the sub-community with *Aposeris foetida - Deschampsia cespitosa* and those on hillocks belonging to the sub-community with *Festuca rupicaprina - Alchemilla alpigena*.

On both forest pasturing sites *Plantago alpina* and *Carlina acaulis*, the characteristic species of the *Plantago alpina - Festuca nigrescens* community of the pure pasturing area, occurred either with little persistence or were completely missing. The *Aposeris foetida - Deschampsia cespitosa* subcommunity occurred both on hillocks and in depressions. However, characteristic hillock species remained limited to hillocks despite the influence of pasturing. According to the features of open spruce stands also species of the *Piceion* and the *Fagetalia* were represented.

Changes in the vegetation cover through protection against pasturing - aboveground

The protection against pasturing caused mainly a change in the combination of species, but did not influence the number of species. Altogether, 118 species were found on the small sample plots. On either forest pasturing site 68 species were counted, while on the pure pasture 101 species were found.

The following species responded to grazing, or the interruption of pasturing, with a change in their dominance:

- Lower dominance: *Crepis aurea, Deschampsia cespitosa, Festuca nigrescens, Nardus stricta, Phleum commutatum*
- Higher dominance: *Agrostis capillaris, Chaerophyllum hirsutum, Leontodon hispidus, Vaccinium myrtillus.*

With a view to soil conservation, the decrease of *Deschampsia cespitosa* is not always positive, as its dense and profound roots improve the stability of the soil (LICHTENEGGER 1994).

Changes in height growth due to pasturing: On nearly all plots the growth in height of the individual species increased as a result of the protection against pasturing and browsing. Compared to the pure pasturing area, the increase was up to 134 % for *Phleum commutatum*, 66 % for *Leontodon hispidus*, 242 % for *Alchemilla glabra*, and 48 % for *Veronica chamaedrys* (Table 1).

Table 1. Height growth of typical species in pure pasture areas.

	Ungrazed		Pasturing	
	Height of inflorescence (cm)	Length of leaves and/or foliage height (cm)	Height of inflorescence (cm)	Length of leaves and/or foliage height (cm)
Phleum commutatum	110	70	47	29
Leontodon hispidus	50	30	30	10
Alchemilla glabra	65	50	19	11
Veronica chamaedrys	40	35	27	13

In STEMMER & PEER 1993 also higher phytomass concentrations were observed for the unutilized plots of the Glockner area (Salzburg), 795 g/m^2 for ungrazed, but only 682 g/m^2 for grazed plots.

Changes in the proportion of grass and herbs as a result of the protection against pasturing: The proportion of grass and herbs is of special importance to the quality of the fodder. If the percentage of grass is too high, the fodder frequently becomes less tasty. On all sample plots the hillock sites, where more herbs are found, were much more browsed than the more grassy depression sites. The highest percentages of grass (70 % - 90 %) was determined in the depressions of the pure pasturing plots.

Forage supply and quality of forage in comparison with Austrian pastures

Sites used for pasturing can be evaluated by means of their yield and the quality of the forage. Forage supply in dt/ha and quality acc. to its energy content (MENKE & STEINGASS 1987) were compared to Austrian grazing plots (Table 2). Exclusively sites on calcareous parent rock were used.

Table 2. Forage supply (dt/ha) and forage quality of Austrian grazing plots (1 dt = 0.1 t).

Location		dt/ha	Forage quality	References
Schulterberg (Pure pasture)	1640 m	81.0	7.59	STEINWENDER, pers. comm.
Schulterberg (Fenced since 1986)	1640 m	81.0	6.64	STEINWENDER, pers. comm.
Schulterberg (Fenced since 1992)	1640 m	81.0	7.01	STEINWENDER, pers. comm.
Altitude profile Johnsbach (Styria)	1700 m	7.38	8.60	SOBOTIK 1995
Altitude profile Johnsbach (Styria)	1500 m	18.53	9.74	SOBOTIK 1995
Altitude profile Johnsbach (Styria)	1300 m	38.20	9.7ß	SOBOTIK 1995
Admont (Styria) 1700 m		12.57	8.18	SOBOTIK 1995
Admont (Styria) 1500 m		12.57	8.67	SOBOTIK 1995
Admont (Styria) 1300 m		31.94	9.04	SOBOTIK 1995
Altitude profile Catena (Carinthia)		4 - 98	-	SOLAR & LICHTENEGGER 1981
Gailtal/Eggeralm (Carinthia) 1760 m		42	-	KUTSCHERA & LICHTENEGGER 1980

As can be seen from Table 2, the fodder supply of the Schulterberg is high as compared to other sites. The yields can be explained by the high grass share of the depression sites. This topographic structure of depressions and hillocks, which is typical of the Schulterberg, is only sporadically found on other sites. Also the low quality values of the forage in the area of investigation are due to those topographic particularities, as the grasses dominant in the depressions are not favoured by the grazing animals.

Changes of the vegetation cover due to the protection against pasturing - subsoil; root-ecological investigations

The root mass, the total length of the root pieces per volume unit at different soil depths, and the length of the root hairs were determined. The roots were divided into thin (diameter < 0.2 mm), medium (0.2 - 2.0 mm) and thick (> 2.0 mm) roots.

Root mass: The results are outlined in Table 3; details are given in SOBOTIK & POPPELBAUM 1995. With reference to the entire soil profile, the root masses varied greatly between individual sample plots and years. The maximum variation was observed on main sample area 1.

Table 3. Mean values of the subterranean root mass (dt/ha, 1dt = 0.1 t).

		Sample area 1 (1620 m)		Sample area 2 (1640 m)		Sample area 3 (1640 m)		
	Year	Pasture	Ungrazed since 1991	Pasture	Ungrazed since 1992	Pasture	Ungrazed since 1992	Ungrazed since 1986
Root Ø	1992	10.07	18.83	31.19	35.48	-	24.48	35.03
< 0.2 mm	1993	12.15	26.31	13.61	9.96	16.54	9.81	11.46
	1994	58.33	61.98	-	-	39.32	46.70	51.04
Root Ø	1992	9.64	28.90	23.30	30.40	-	5.47	13.93
0.2-2.0 mm	1993	27.78	33.20	21.81	20.64	19.79	10.24	14.33
	1994	21.09	42.19	-	-	23.24	21.70	27.87

The big annual variations observed on all sample plots indicate the strong influence of the annual weather conditions; in 1994, for instance, the variations might have been due to the extremely dry and hot summer. According to the present investigations the big differences in root mass between the individual years are primarily due to the more intense formation of roots by the existing vegetation. For example, *Aposeris foetida* increased markedly on the forest pasturing sites between 1992 and 1994 and inside the game-proof fences; the rich, shallow nodal roots of that plant might have contributed to the increase in root mass. Using a meadow of yellow oat grass as an example, the influence of the weather conditions on the root mass were described in the framework of the Solling project (Germany; SPEIDEL 1986). According to the two-year average the mean value of root mass increased from 90 % to 110 % at the onset of summer aridity in May 1976 (precipitation April - September 1976 approx. 260 mm, 1975 approx. 470 mm).

By means of root-anatomical investigations it was possible to identify the majority of the most profound roots as belonging to *Deschampsia cespitosa* and *Nardus stricta*. A balanced distribution of roots in individual soil horizons improves the stability of the soil; at the sub-alpine level that is found predominantly on sites having a southern aspect (KUTSCHERA & MITTER 1971). On all sample plots between 54 % and 92 % of the root mass of the fine roots found in depths of 0 - 10 cm; between 5 % and 15 % in depths of 10 - 20 cm (in exceptional cases up to 41 %), and between 1.4 % and 5.3 % in depths of 20 - 30 cm. The weight percentages of the roots of medium thickness showed similar values.

That primarily dry years lead to a deterioration of the status of forests might also be due to the fact that the understorey with its excessive increase of roots competes strongly with the tree roots (WELLER 1965). The year 1994, which was characterized by particularly marked periods of heat and dryness, led to an increase in root mass by up to 479 % on the forest pasture at 1620 m a.s.l. The observation that, in addition, the major part of the roots are to be found in the uppermost 2 to 10 (20) cm even reinforces this effect for the shallow-rooting spruce.

Total length of the root pieces: The total length of the root pieces was determined only in the uppermost soil layer (soil depth of 0 - 10 cm) and only on main sample area 3. The high workload required this limitation. Altogether, the total length of the root pieces varied between approx. 5,900 and 33,400 km/ha (Table 4).

Table 4. Total length of roots on pure pastures and non-pasturing areas.

Form of pasture	Root length < 0.2 mm (km/ha)	Root length 0.2-2 mm (km/ha)
Pasture	33,385	5,885
Fenced since 1986	16,250	11,068
Fenced since 1992	16,406	12,474

The greatest total length of fine roots was calculated for the grazed plots. That observation and the smaller total length of the roots of medium thickness on the grazed plots might largely be due to differences in the species composition of the plant stands. For instance, *Phleum commutatum*, which has particularly fine roots, occurs more frequently on grazed plots. On the other hand, that may also indicate that pasturing encourages the development of young, thin roots, but reduces the development and life of roots of medium thickness. Those issues require further investigations.

Root hairs: The length of the root hairs was determined only on main sample area 3. On the grazed plot, the root hairs reached lengths of up to 0.8 mm; on the one which had been ungrazed since 1992, such of up to 0.5 mm. On the plot which had not been browsed or grazed since 1986 the root hairs reached lengths of up to 4.0 mm. Those differences may among other things be due to the higher relative humidity of the hollows in the soil, which are big on that sample plot.The effects of the protection against pasturing were interesting in respect of the loosening of soil and the differences in the formation of root hairs in such loosened soil layers. As an example, Figure 2 shows soil profiles inside the plots fenced in since 1986 as compared to the pure pasture. Figure 3 shows root hair zones of those soil layers.

Discussion

The protection against pasturing on the sample plots had only a minor effect on number and shifting of species in the depressions. Similar long-term observations carried out on the Piffkar (Glockner area, Salzburg) by GRIEHSER 1993 showed the same results. In 1992 the protection against pasturing led to the smallest number of species in the depressions inside the game-proof fence; since then, however, a continuous increase has been observed. Inside the game-proof

Fig. 2. Influence of grazing on the soil condition.

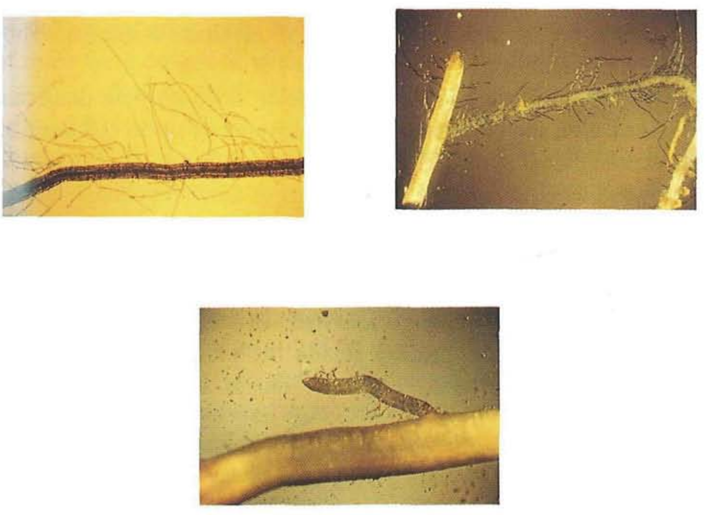


Fig. 3. Development of root hairs.
a: Ungrazed since 1986
b: Ungrazed since 1992
c: Grazed

fence of the forest pasturing plot at 1620 m *Vaccinium myrtillus* increased rather quickly, a fact which was pointed out also by SPATZ & KLUG-PÜMPEL 1978 in connection with abandoned mountain pastures. The most marked changes due to protection against pasturing and browsing were observed inside the game-proof fence which had been built already in 1986, and it should be noted that (compared to the ungrazed area) the most remarkable changes occurred already in the 6th year of observation. Apart from the general disappearance of *Phleum commutatum*, a considerable decrease of *Festuca nigrescens*, an increase of *Leontodon hispidus*, and an increase of species sensitive to grazing were observed inside the fence (from 8 to 13), taking into account the entire area.

As compared to other results, the values of the total root masses were rather low: For instance, on sites of comparable altitudes in the Styrian Limestone Alps root masses of 52.37 to 310.12 dt/ha were determined. Large variations in root substance were found also in the course of investigations on the Mitteralm at the northern gradient of the Glockner Road, where values between 7.47 and 107.0 dt/ha were determined. As compared to this, STEMMER & PEER 1993 found average amounts of 184.4 dt/ha on pastures located at 1770 m and 2420 m a.s.l. and of 236.7 dt/ha on ungrazed plots.

From a Styrian site (Irdning, 700 m a.s.l.) the results of several years of comparative investigations about grazed plots and mowed meadows are available: On a yellow oat grass meadow mowed twice a year a root mass of 14 - 21 dt/ha was determined, while on the adjoining fallow deer pasture it was only between 3.9 and 4.42 dt/ha (STEINWENDER & al. 1990). On a sheep pasture (dogstail grass), equally located at Irdning (646 m a.s.l.), the root substance was 4.43 dt/ha, compared to 5.48 dt/ha on the immediately adjoining mowed meadow. Along Rhine embankments located at lower altitudes (400 m a.s.l.) LUTZ 1993 determined root substances between 1.56 and 5.46 dt/ha, the fertilized sites reaching much lower values than the less fertilized or unfertilized sites. The relatively low values of the root substances can be explained by the fact that due to climatic influences the assimilates require less time to turn into foliage.

Regarding the lengths of the roots GASS & OERTLI 1980 found the biggest lengths (6,665,100 km/ha) on the fallow grounds. However, all those plots are located at low altitudes. No similar reference data are available from subalpine pasture sites. On the comparable areas of the Schulterberg the biggest lengths were much lower (with 39,000 km/ha on the grazed areas).

Also GISI & al. 1979 and STEMMER & PEER 1993 described the marked loosening of the top soil by the example of uncultivated grounds. In his pedological evaluation of these plots, ENGLISCH 1992 found humus covers of 3 cm thickness as compared to only 0 to max. 0.75 cm on the area outside the fence which was opened for grazing. The effect of the humus covering and the formation of more hollow space shows also in the growth forms of the species. Examples of that observation are *Festuca nigrescens* and *Carlina acaulis*: For instance, the cluster-wise growth of *Festuca nigrescens* is frequently unclear, while *Carlina acaulis* develops considerably thicker tap roots and often multi-pedunculate inflorescences. On the same sample plots MUTSCH 1995 observed impairments of the soil, such as acidification and a higher C/N ratio; results of measurements carried out by the Federal Institute of Alpine Agriculture Gumpenstein showed pH values between 4.1 and 4.7 inside the game-proof fence, while on similar sample plots pH values between 5.1 and 6.3 were measured; the C/N ratio was between 10 and 14 (inside) as compared to 7 - 9 (outside). The acidification of the soils following a cutting stop and grazing were observed also by TÜXEN 1970 und SCHIEFER 1982.

The available results allow the following conclusions:

- The vegetational surveys included 118 species, which corresponds to an abundant pasture vegetation.
- Already few years after pasturing had been stopped, changes in the vegetation cover were obvious. There was a marked shift in favour of the herbaceous plants.
- The protection against pasturing caused a change in the combination of species, but did not affect the number of species.
- The growth of the vegetation cover in height can be used as an indicator of the influence by pasturing.
- Certain species are suited as indicators of the effects of a lack of pasturing.
- Protection against grazing leads to an reduced occurrence of *Deschampsia cespitosa*, which may have negative effects on the stability of the soil.
- Compared to the yields of other Austrian areas used for grazing, the aboveground biomass of pure pastures is relatively high and offers good forage supply. The quality of the forage, however, deteriorates with increasing time of the areas not being used as pastures.
- Root masses appear to be more influenced by climatic conditions than by pasturing.
- Pasturing causes a significant increase in the total length of the fine roots and, on the other hand, a decrease of thick roots.
- According to the rather continuous distribution of roots by depth damage by over-grazing is not remarkable.
- The loosening of the soil structure, which follows interruptions of pasturing use, is reflected in the form of the root hairs, particullary in their length. This feature is suited to prove short-time changes by different uses.

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