Bocconea 29: 21-32
https://doi.org/10.7320/Bocc29.021
Version of Record published online on 5 August 2021

Conradin A. Burga & Stefan Bührer

Mountain ash forests of the Central and Southern Alps: Grisons-Ticino (Switzerland)-Verbano-Cusio-Ossola (North Italy)

Abstract

Burga, C. A. & . Bührer, S.: Mountain ash forests of the Central and Southern Alps: Grisons-Ticino (Switzerland)-Verbano-Cusio-Ossola (North Italy). — Bocconea 29: 21-32. 2021 — ISSN: 1120-4060 printed, 2280-3882 online.

Mountain ash (*Sorbus aucuparia*) is widespread in nearly whole Europe from sea level to timberline. On north exposed peaks of some mountains of the Southern Alps (Ticino/ Switzerland and North Italy/ Verbano-Ossola) small mountain ash forests build the forest limit above 1500 m, so at Monte Lema, Monte Morissolo, I Balmit and Mottarone. Mountain ash often occurs on former forest clearings as pioneer tree as secondary plant succession. On some sites, mountain ash will be replaced later by beech as climax species. At all sites, we recognized a weak or missing generative mountain ash reproduction. One reason for that could be the dense grass cover of small-reed, *Calamagrostis* spec. which inhibits the establishment of rowan seedlings; other reasons could be insect and game damage, mycosis and other diseases. Vegetative propagation like root bulbils, suckers and shoots from stump are important survival strategies of mountain ash. So, at some sites have been recorded a high share of polyphyletic single young trees. At all sites, count of annual rings of 25-50 mountain ash trees revealed an average age of 40-55 years. Green alder and mountain ash often occur together within the *Alnetum viridis* as well as in the mountain ash forest. In the green alder bush, mountain ash occurs only as single trees, whereas *Alnus viridis* can dominate in both plant communities. At the southernmost sites, there is a marked weak abundance of green alder due to dryer climate. Within mountain ash forests of the Southern Alps, the typical tall perennial herbs of the green alder bush are more or less absent because of low rainfall during summer and possibly absence of green alder. At the driest sites grow more grass species, mainly small-reed (*Calamagrostis* spec.). Based on our vegetational surveys of mountain ash forests at the sites mentioned above, we suggest a new sub-association *Alno viridi-Sorbetum aucupariae calamagrostietosum* prov. of *Alno viridi-Sorbetum aucupariae* prov. or eventually a new association *Calamagrostio-Sorbetum aucupariae* prov.

Key words: European range, Central and Southern Alps, biology of dispersal, secondary forest succession, South Alpine mountain ash forests, green alder bush. .

Introduction and problem issue

Mountain ash or rowan is an attractive slender deciduous tree 10-20 m in height with silvery-brown bark, creamy-white spring flowers and brilliant orange autumn berries (Fig. 1). The rowan provides as a valuable crop berries in early winter consumed by birds.

The trees reach maximal 27 m in height in sheltered places, but much less in exposed sites. On almost bare mountain rocks, they grow as bushes. Mountain ash is a light demanding pioneer tree with fast early growth, but ephemeral, reaching maximum ages of 80 to 100 years. Young rowan trees are very shadow tolerant. It grows on wet, dry and nutrient rich acid soils. Rowan's hard and elastic timber is suitable for different technical use, e.g. furniture or stress-tolerant components of machines in the past.

Mountain ash occurs in a wide European range from Spain, South Italy, North Greece, North Turkey, Black Sea to the Caucasus. The Eastern European range border is not well known, it fits approximately with the course of Wolga and the Ural mountains. Mountain ash reach on the northern tree limit in North Norway its northernmost occurrence at 71° N (Hegi 1995; Roloff & al. 2010; Steiger 2010). The Swiss range of *Sorbus aucuparia* is shown on two maps, published by Brändli (1996). On calcareous soils mountain ash is often replaced by whitebeam (*Sorbus aria*).

Mountain ash occurs as single trees or as small stocks in all Central European altitudinal vegetation belts. It often occurs as a pioneer tree in secondary forests together with green alder (*Alnus viridis*), several willow species (*Salix* spec.), elder (*Sambucus* spec.), birch (*Betula* spec.), and alder buckthorn (*Frangula alnus*). In some nurse crops, rowan occurs as a dominant tree (e.g. *Piceo-Sorbetum aucupariae, Sambuco-Salicion capreae, Epilobio-Salicetum*) (Oberdorfer 2001). In climax forest communities of montane and subalpine forests on acid soils rowan is regularly present. In the subalpine belt a typical rowan occurrence can be recorded in green alder and mountain pine scrub or in larch and larch-Swiss stone pine forests. In the colline belt rowan is present in acid mixed beech forests, but also in calcareous mixed oak forests and riparian forests as well as on forest edges and hedges together with other shrubs.

In Canton of Ticino (Switzerland) and Verbano-Cusio-Ossola (Lago Maggiore, N-Italy) mountain ash occurs on north exposed slopes at the forest limit as local pure stand growth. On Monte Gradiccioli (1780 m a.s.l., Ticino) it reaches one of the highest point. This pure stands of mountain ash often form polyphyletic "colonies" up to 20 trunks. It seems that troops of mountain ash are more resistant at this extreme mountain sites than single one-stemmed individual trees. Moreover, some authors suppose that pure stands of mountain ash are supported through the lack of browsing by game (Hari & al. 1993).

This study deals with vegetational, ecological and plant sociological aspects of *Sorbus aucuparia* within the area of the southern slope of the Central Alps of the region Grisons-Ticino (Switzerland)-Verbano-Cusio-Ossola (N-Italy). The first study to small mountain ash forests on the forest limit of the region Monte Lema - Monte Gradiccioli - Monte Tamaro (Ticino) is by Hari & al. (1993). The present study is an enlarged investigation to Central and Southern Alpine mountain ash forests on the timberline.

The following question issues have been investigated: (1) Under which conditions exist pure stands of mountain ash, and where do they occur within the study region? (2) Which are the characteristics of mountain ash biology of dispersal (growth and age-structure)? (3) What plays a role mountain ash occurrence in green alder scrub, and are mountain ash forests a climax plant community occurring above the potential natural beech forest range? (4) Can we South Alpine mountain ash forests at the potential forest limit define as a new plant community?

Fig. 1. *Sorbus aucuparia*. Photo: C.A. Burga 2003.

Study sites

The study area on the southern slope of the Central Alps of the region Grisons-Ticino (Switzerland)-Verbano-Cusio-Ossola (N-Italy) is shown in Fig. 2 (Fig. 2).

The transect starts in the subalpine zone of Tschamut (1667 m, Canton of Grisons) near the Oberalp pass where dense populations of Alnetum viridis occur, within mountain ash grows as single tree. This site lies within sedimentary gneiss rocks (muscovite gneiss) of the Tavetscher intermediate massif, which is located between the Aare and Gotthard massif at the SE border of the Helveticum (Gnägi & Labhart 2015). The investigated vegetation plots on acid brown soils (silicate moraine) are located on the northern slope of Piz Cavradi above Tschamut. The next four sites are located in the southern Alpine Insubric crystalline zone or in the Ivrea zone with gneiss and crystalline schist (mainly two-mica granite). The site of Monte Lema (1620 m) lies in the Ticino Alps NW of Lugano. The study site on acid brown soil (silicate scree) near the top was former used as ski slope. The vegetation consists of a mosaic of mat-grass pasture (Nardion) and ericaceous scrub (mainly *Vaccinium myrtillus* and *Rhododendron ferrugineum*) with single mountain ash seedlings. Nearby grows a small mountain ash forest above the upper limit of beech forest (Fig. 3). The next two study sites Monte Morissolo (1277 m) and I Balmit (1605 m) are located in the Verbano-Cusio-Ossola region (Italy), W of Ticino Alps. The site Monte Morissolo above Cannero/ Lago Maggiore was during World War I treeless, then it was used as pasture. Today there grow on acid brown soils beech and mountain ash forests with dense undergrowth of small-reed (*Calamagrostis arundinacea* and *C. villosa*) and Alpine rose (*Rhododendron ferrugineum*). On the site I Balmit, a mountain ridge of Monte Zeda (2156 m) north of Intra, grows on acid brown soils above the upper beech limit (ca. 1500 m) the largest mountain ash forest of this study area of ca. 1 square km.

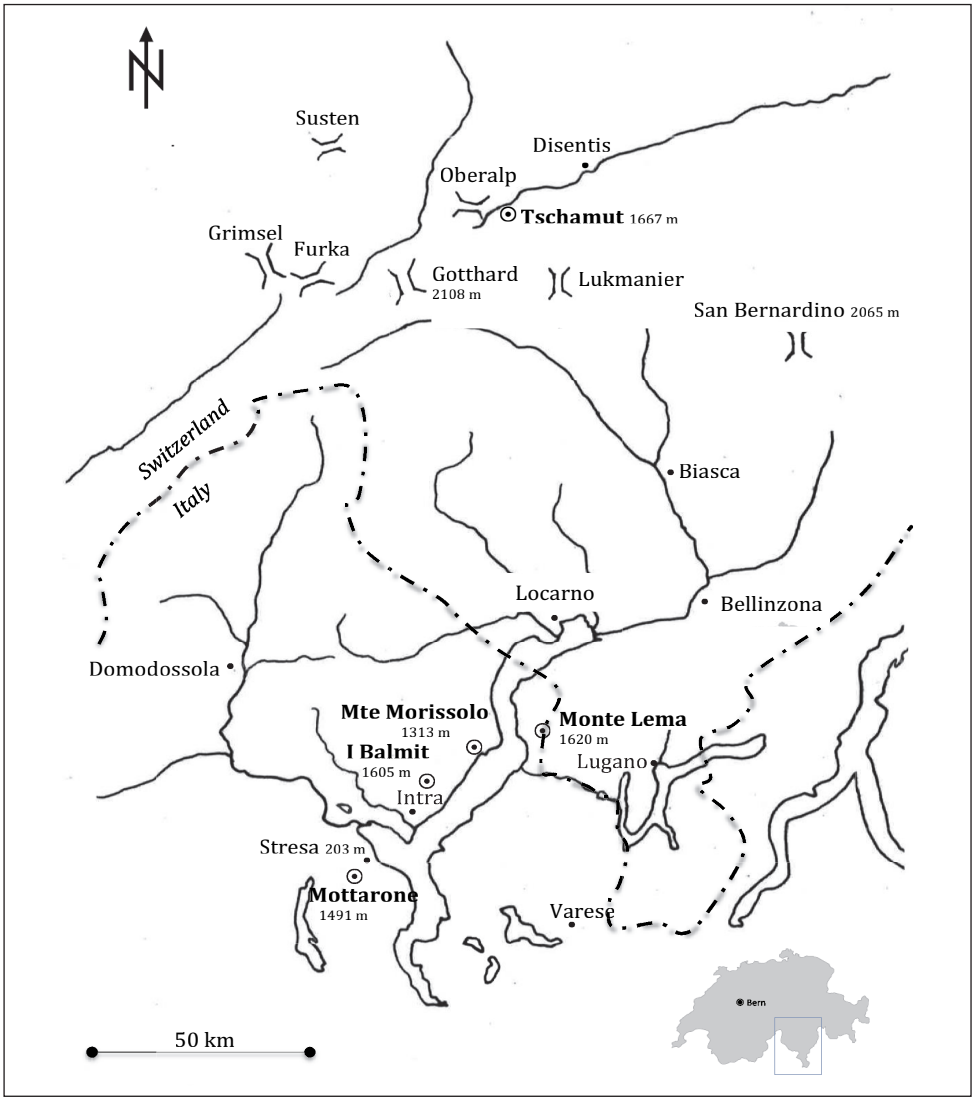

Fig. 2. Map of study sites Grisons-Ticino (Switzerland) and Verbano-Cusio-Ossola (N-Italy).

It nearly reaches the top in 1605 m and lies in the National Park "Val Grande". The mountain I Balmit shows the following well developed vertical vegetation zonation: montane beech forest up to ca. 1500 m, above it mountain ash forest, followed by a small green alder and Alpine rose scrub section, and at the top mat-grass pasture (Nardion). The 5th study site Mottarone (1491 m) above Stresa is one of the last southern foothills before the Po Plain. During the 1920ies the forest limit was lowered at 800-850 m with a tree limit at ca. 1000 m due to ski tourism.

Afterwards it was reforested with birch and Norway spruce (Keller 1931). On the former skiing ground a dense mountain ash forest settled on acid brown soil (Fig. 4). In addition there grow green alder (*Alnus viridis* and *A. brembana*), sycamore maple (*Acer pseudoplatanus*) and laburnum (*Laburnum* spec.); there occur only few Alpine rose individuals. The vegetation of this site is different to the other described mountain ash sites of this study. A check-list to the flora of the investigated sites of Verbano-Cusio-Ossola has been established by Antonietti (2002, 2005).

The site Tschamut is located in the climate region of NW Grisons where N and NW winds bring the main yearly precipitations of ca. 1500 mm (thunderstorms during 15-20 days per year). The average year temperature is ca. 1°C (yearly sunshine hours 1600-1700) (Kirchhofer 1982, 1984, 1991). The other sites of Ticino and Verbano-Cusio-Ossola (Italy) are situated in the south Alpine or Insubric climate region with yearly precipitations of 1800-2200 mm, mainly during summer (May-August) with thunderstorms on 50-55 days per year. The summer is hot, whereas winter has mild temperatures. This south Alpine region enjoys 2100-2300 yearly sunshine hours (the Swiss maximum). But during winter there is more fog from the Po Plain (Urfer & al. 1979; Kirchhofer 1982, 1984, 1991). The year mean temperature (°C) and year precipitations (mm) for the south Alpine investigation sites are as follows: Monte Lema (ca. 4.9/ca. 1500), Monte Morissolo (ca. 6.5/ca. 1800), I Balmit (ca. 4.3/ca. 2000), and Monte Mottarone (ca. 5.0/ca. 2400) (Kirchhofer 1982, 1984, 1991).

Fig. 3. Monte Lema (1620 m). On the top grows a small mountain ash forest above the upper limit of beech forest. Within the herbaceous layer dominates *Calamagrostis villosa*. Photo: S. Bührer 2007.

Fig. 4, Mottarone (1491 m) above Stresa. On a former skiing ground, a dense mountain ash forest settled on acid brown soil. Photo: S. Bührer 2007.

Methods

The selected sites of small mountain ash forests (see above) have been investigated according to the following methods.

(1) Vegetation surveys according to Braun-Blanquet (1964). The degree of coverage 2 (10-25%) has been modified as follows: 2.1 (10 to <15%), 2.2 (15 to <20%) and 2.3 (20 to <25%). There were recorded flowering plants and ferns (no mosses and lichens) on plots of ca. 100 m^2. Each vegetation survey has been carried out through two independent persons.

(2) Dendrochronology: Counting of annual rings (number and ring width) of mountain ash stems with the help of wood drilling cores at a height of 1.3 m above surface. For several individuals could occur a source of error due to polyphyletic growth, game damage or light deficiency. Only trees reaching the forest canopy with the thickest stems have been chosen. The width of annual rings has been classified in three groups: a) large rings, b) medium width, and c) small rings. There are to consider errors due to compression wood and tension wood. This investigation should only give some information to the trend of rowan growth at the investigated sites.

(3) Count of young rowan trees. At the site Monte Morissolo, the generative rejuvenation of rowan trees of less than 20 cm height has been studied on different plots of 4 m^2 within the rowan forest, at the forest edge and at the adjacent meadow. The most part of the recorded young rowan trees are polyphyletic colonies of more than 10 stems. This rejuvenation strategy of rowan seems to be better adapted on extreme sites and allow a longer longevity than monophyletic individuals.

(4) Identification of insect damages through beetles on the sites of Monte Morissolo and I Balmit.

Results

Vegetation aspects to sites with mountain ash forests

Within the study area, mountain ash grows on north exposed sites free of avalanches in 1200 - 1650 m a.s.l. It is important to distinguish mountain ash sites below and above the upper beech limit, because here beech is the main competition tree for mountain ash. The investigations show that rowan forests below the beech limit at ca. 1500 m will be driven out. So, small secondary rowan forests of Monte Morissolo in 1200 – 1300 m and Monte Mottarone in ca. 1400 m grow on former sites of beech forest, which have been cleared for cultivation (mainly by gain of charcoal at the end of 19th century) and for ski slope or pasture respectively. In this case, rowan forests represent a pioneer stage of secondary reafforestation after human activities ceased. At present at Monte Morissolo, the most part of rowan trees are dead and replaced by beech. The mountain ash forest of Monte Mottarone is much younger because this site has been used as ski slope and pasture until the 1950ies. So, there is a richer herbaceous layer compared with the oldest mountain ash site of Monte Lema (47 and 32 flowering plant species respectively). The mountain ash forest of Monte Mottarone represents a young stage of secondary reafforestation, in contrast to Monte Morissolo.

At the onset of the 19th century, vast alpine areas of the Southern Alps were deforested for pastures. After decline of agriculture in this area, a marked secondary spread of small mountain ash forests has been recorded within and above the beech forest range (Ceschi 2006).

Mountain ash forests of Monte Lema and I Balmit lie above the upper beech limit. Today, they could eventually represent a climax mountain ash forest. The site I Balmit was formerly partly used as pasture; after this use was given up, mountain ash forest spread. After ca. 20 years of growth, tree rings of mountain ash became smaller, eventually an indicator of stronger tree competition. At the site I Balmit, rowan trees of similar ages show not an optimal vitality, and they form a weak mixed population age-structure. Rowan forests of Monte Lema are much older as they represent the natural-potential forest community. Compared with I Balmit and Monte Morissolo, the age-structure of trees and the herb and shrubs layer are more divers.

Natural regeneration, growth form and age structure of mountain ash

At the investigated sites, we recognized a weak or missing generative mountain ash reproduction. On all sites, there were only few seedlings in the mountain ash forests, even in the old forest of Monte Lema. At Monte Morissolo, three vegetation plots, i.e. neighbour pasture, rowan forest edge and rowan forest, were checked regarding rowan seedlings (smaller than 10 cm). The most part of them were recorded in the pasture, at the forest edge a few and no seedlings inside the forest. So, this weak occurrence or absence of rowan seedlings inside the forest is difficult to explain. The following hypothesis can be considered as possible reasons. Dense grass cover, mainly of small-reed species (*Calamagrostis villosa* and *C. arundinacea*), recorded on different sites, could inhibit growth of seedlings. On the other hand it is known that at higher altitudes the capacity for living and dry weight of mountain ash seeds is declining (Barclay & Crawford 1984). Mainly at Monte Morissolo and I Balmit has been recognized a marked insect damage. Different authors reported to related damages, e.g. Schmidt (1989), Lemme (1995) and Erlbeck (1998). Other damages on rowan trees have been reported like game damage, mycosis and viral diseases, but all these impacts are not considered as lethal. So, we suppose a dense grass cover of small-reed (*Calamagrostis villosa* and *C. arundinacea*) and/or a combination of different causes for this reduced natural mountain ash regeneration.

At Monte Morissolo, four plots of each 100 m^2 have been checked regarding vegetative rowan propagation, i.e. the amount of polyphyletic single young rowan trees. The plots revealed single rowan trees with 1 to max. 27 stems. Moreover, only 21 rowan trees of a total of 125 checked individuals showed shoots from stump. Most of them are very thin stems with few chances to survive. The main reason for that is game damage and beetle infestation (e.g. *Gonioctena* spec.) (Erlbeck 1997). Nevertheless, Hari & al. (1993) described rowan forests without seed formation (e.g. at the timber limit), but which produce vegetative propagation like root bulbils, suckers and shoots from stump as an important survival strategy. At Monte Morissolo it is not clear whether the rowan forest will rejuvenate or develop in the future. All in all, this could eventually explain the small size and rare occurrence of rowan forests in the Southern Alps. In contrast to that, at Tschamut (Central Alps) where rowan is associated with green alder within the *Alnetum viridis*, rowan trees show a lot shoots from stump and generally a higher vitality.

At all sites, count of annual rings of 25 – 50 rowan trees revealed an average age of 40 – 55 years. The different frequencies of age classes of the single sites are conspicuous. The frequencies of age classes of the S-Alpine sites can be explained with former change of agricultural use. Whereas rowan trees within the *Alnetum viridis* of Tschamut (Central Alps) show an unbalanced age class of 51-55 years due to high avalanche frequencies.

We recorded mainly polyphyletic rowan trees with 40 or more stems (e.g. at Monte Morissolo and Monte Mottarone). On steep slopes the trees often show one-sided growth due to snow creep and soil sliding. So, rowan is perfectly adapted on different sites and climate conditions.

Discussion

Why occur mountain ash forests mainly in the Southern Alps?

Green alder (*Alnus viridis*) occurs as *Alnetum viridis* mainly in the Swiss Northern and Central Alps (e.g. site Tschamut), where single trees of mountain ash are associated within the *Alnetum viridis* bush. Avalanche slopes, where Norway spruce growth is inhibited, are mainly covered with green alder. The Southern Alpine climate with dry phases during summer is less suitable for green alder and its tall perennial herbs, which demands regular water supply during the whole year (Richard 1968a; Rubli 1976; Ellenberg 1996; Wettstein 1999; Oberdorfer 2001). So, N-exposed steep slopes above the upper beech limit (ca. 1500 m a.s.l.) of the Southern Alps are favoured sites of mountain ash (up to ca. 1800 m a.s.l.). Here, only single green alder bushes are scattered within the mountain ash crops at the most humid sites. Besides green alder, there occur also *Alnus brembana*, distinguished from *Alnus viridis* by lower height and smaller leaves and fruit cones, a floristic element within the insubric beech forest belt (Landolt 1993). The vegetation profile through the Central Alps from NE to SW (Säntis – Mottarone) shows the typical occurrence of the Alnetum viridis on north-slopes and the small mountain ash forests (Alno viridi-Sorbetum aucupariae prov.) at the subalpine belt of the Southern Alps, mainly in north exposition.

South Alpine mountain ash forest, a new forest community

Many mountain ash forest communities of Switzerland, Germany and France have been described (e.g. Moor 1947, 1952; Richard 1968b; Passarge 1987; Hari & al. 1993; Pott 1995; Maier 1997; Oberdorfer 2001; Carraro 2010; Steiger 2010). Hari & al. (1993) named the mountain ash forest of Monte Lema *Alno viridi-Sorbetum aucupariae* prov. But the herbaceous undergrowth at the sites of Monte Lema, Monte Morissolo, I Balmit and Mottarone shows a dominance of small-reed species (*Calamagrostis villosa* and *C. arundinacea*) with relative constancy classes of IV to V (Fig. 5).

So, we suggest a new sub-association of *Alno viridi-Sorbetum aucupariae* prov. with dense herbaceous undergrowth of *Calamagrostis villosa* and *C. arundinacea*, called *Alno viridi-Sorbetum aucupariae calamagrostietosum* prov. or eventually a new association *Calamagrostio-Sorbetum aucupariae* prov. (Fig. 5). Further plant sociological research is needed in the Southern Alps to determine definitively this new mountain ash forest community. Outside of the green alder-mountain ash plant community, *Sorbus aucuparia* occurs accidentally in many other forest communities, especially in subalpine silver fir and Norway spruce forests (e.g. Leibundgut 1991; Brändli 1996; Maier 1997).

Alno viridi-Sorbetum aucupariae calamagrostietosum prov. and Alnetum viridis					
Index species: Flowering plants and ferns (without accessory species of weak coverage)	**Relative constancy classes I - V** (class steps of 20%)				
	Investigated sites				
	Tschamut	**Mte Lema**	**Mte Morissolo**	**I Balmit**	**Mottarone**
Cicerbita alpina	V				
Adenostyles alliariae	V				
Peucedanum ostruthium	V				
Achillea macrophylla	V				II
Viola biflora	V				
Rumex alpestris	V				
Saxifraga rotundifolia	IV				
Ranunculus platanifolius	II				
Poa nemoralis	IV		V		
Stellaria nemorum s.l.	IV			II	
Veratrum album ssp. *lobelianum*	V	II	II		V
Homogyne alpina	II	I		III	II
Chaerophyllum hirsutum aggr.	II				II
Vaccinium myrtillus	IV	V	V	V	V
Rhododendron ferrugineum	II	V	V	III	IV
Athyrium distentifolium	V	V	V	V	
Athyrium filix-femina	III		V	V	V
Dryopteris dilatata	III	V	II	III	
Alnus viridis*, partly incl. *Alnus brembana	V	V	IV	V	V
Sorbus aucuparia	II	V	V	V	V
Calamagrostis arundinacea		IV	V	V	IV
Calamagrostis villosa		V	V	V	II
Avenella flexuosa		V	V	V	V
Maianthemum bifolium		V	V	V	V
Phegopteris connectilis		V	V	V	V
Luzula nivea		III	V	V	V
Oxalis acetosella		V	V	III	III
Deschampsia cespitosa		V		V	III
Luzula sylvatica aggr.		I	II	I	V
Luzula pilosa		V			
Polygonatum verticillatum				IV	III
Senecio ovatus					V
Solidago virgaurea s.l.				III	
Vaccinium vitis-idaea					IV
Prenanthes purpurea					III
Acer pseudoplatanus		I	I		II
Fagus sylvatica			I	I	
Betula pendula			II		

Fig. 5. Plant sociological analysis of vegetational surveys of mountain ash forests of the Central and South Alps.

Acknowledgements

We are grateful to Verena Bührer and Richard Bühler for their support in fieldwork and to Petra Kauer-Ott for her support creating the figures.

References

Antonietti, A. 2002: Fortschritte in der Floristik der Schweizer Flora (Gefässpflanzen). 64. Folge (Primo contributo alla conoscenza della flora delle Valli Ossolane). – Bot. Helv. **112/2:** 173-200.

— 2005: Flora del Verbano Cusio Ossola. Check-list delle piante vascolari del VCO aggiornata al 30 Settembre 2004. – Quadri di Natura e Paesaggio del Verbano Cusio Ossola, **4.** – Verbania.

Barclay, A M. & Crawford, R. M. M. 1984: Seedling emergence in the rowan (*Sorbus. aucuparia*) from an altitudinal gradient. – J. Ecol. **72:** 627-636.

Brändli, U.-B. 1996: Die häufigsten Waldbäume der Schweiz. Ergebnisse aus dem Landesforstinventar 1983-85: Verbreitung, Standort und Häufigkeit von 30 Baumarten. – Berichte der Eidgenössischen Forschungsanstalt für Wald, Schnee und Landschaft **342:** 219-222.

Braun-Blanquet, J. 1964: Pflanzensoziologie, 3rd ed. – Wien.

Bührer, S. 2007: Die Vogelbeerwälder der Alpensüdseite. – Diploma thesis, Department of Geography, University of Zurich.

Carraro, G. 2010: Le tipologie forestali del Cantone Ticino e loro tendenze evolutive. Sezione forestale cantonale, ufficio della selvicoltura e del demanio. – Bellinzona.

Ceschi, I. 2006: Il bosco del cantone Ticino. – Bellinzona.

Ellenberg, H. 1996: Vegetation Mitteleuropas mit den Alpen. 5th ed. – Stuttgart.

Erlbeck, R. 1997: Die Vogelbeere. – Unser Wald **5:** 139-141.

— 1998: Die Vogelbeere – ein Porträt des Baum des Jahres 1997 (2–13). – In: Beiträge zur Vogelbeere. Berichte aus der Bayerischen Landesanstalt für Wald und Forstwirtschaft (LWF). – Freising.

Gnägi, C. & Labhart, T. 2015: Geologie der Schweiz. – Bern.

Hari, T., Leisinger, U. & Zysset, S. 1993: Vogelbeerwald (*Sorbus aucuparia* L.) an der Waldgrenze im Gebiet M. Lema – M. Gradiccioli – M. Tamaro, Malcantone (Tessin). – Zürich.

Hegi, G. 1995: Illustrierte Flora von Mitteleuropa, vol IV, part 2B. Spermatophyta: Angiospermae: Dicotyledones 2(3). 2nd edn. – München.

Keller, P. 1931: Die postglaziale Entwicklungsgeschichte der Wälder von Norditalien. – Veröffentlichungen des Geobotanischen Instituts Rübel in Zürich **9:** 37- 42.

Kirchhofer, W. 1982, 1984, 1991: Klimaatlas der Schweiz. Erste, zweite und vierte Lieferung, Bundesamt für Landestopographie. – Wabern-Bern.

Landolt, E. 1993: Die systematische und pflanzensoziologische Stellung von *Alnus brembana* (*Betulaceae*) in den Südalpen. – Fragm. Flor. Geobot. Suppl. **2(2):** 521-537.

Lauber, K., Wagner, G. & Gygax, A. 2012: Flora Helvetica. 5th ed. – Bern.

Leibundgut, H. 1991: Unsere Waldbäume. Eigenschaften und Leben. – Bern.

Lemme, H. 1995: Die Gefährdung der Ebereschen-Pionierbestockungen der Kammlagen des östlichen Erzgebirges durch Insekten. – Pp. 143-145 in: LÖBF (ed.) Weichlaubhölzer und Sukzessionsdynamik in der naturnahen Waldwirtschaft. Schriftenr. Landesanst. Ökologie, Bodenordnung und Forsten Nordrhein-Westfalen, **4.**

Maier, J. 1997: *Sorbus aucuparia*. – Pp. 223-238 in: Roloff, A., Weisgerber, H., Lang, U. M. & Stimm, B. (eds) 2010: Bäume Mitteleuropas. – Weinheim .

Moor, M. 1947: Die Waldpflanzengesellschaften des Schweizer Juras und ihre Höhenverbreitung. – Schweiz. Zeitschr. f. Forstwesen **98:** 1-17.

— 1952: Die Fagion-Gesellschaften im Schweizer Jura. – Beiträge zur geobotanischen Landesaufnahme, **31.**
Oberdorfer, E. 2001: Pflanzensoziologische Exkursionsflora. 8th ed. – Stuttgart.
Passarge, H. 1987: Wildobst-Gehözgesellschaften. – Tuexenia **7:** 381-410.
Pott, R. 1995: Die Pflanzengesellschaften Deutschlands. – Stuttgart.
Richard, L. 1968a: Ecologie de l'Aune vert. – Doc. Carte Vég. Alpes **6:** 107-158.
— 1968b: Quelques groupements végétaux à la limite supérieure de la forêt das les hautes chaines du Jura. – Vegetatio Acta Geobot. **16:** 206-219.
Roloff, A., Weisgerber, H., Lang, U. & Stimm, B. (eds) 2010: Bäume Mitteleuropas. – Weinheim.
Rubli, D. 1976: Waldbauliche Untersuchungen in Grünerlenbeständen. – Beiheft zu den Zeitschriften des Schweizerischen Forstvereins, **56.**
Schmidt, O. 1989: Zur Gefährdung der Vogelbeere durch Insektenfrass. – AFZ **44:** 358-359.
Steiger, P. 2010: Wälder der Schweiz. – Bern.
Urfer, C., Gensler, G., Ambrosetti, F. & Zenone, E. 1979: Regionale Klimabeschreibungen. 2. Teil Alpennordhang, Graubünden und Alpensüdseite. – Pp. 323-407 in: Beiheft zu den Annalen der Schweizerischen Meteorologischen Anstalt (Jahrgang 1978). Schweizerische Meteorologische Anstalt, Zürich.
Wettstein, S. 1999: Grünerlengebüsche in den Schweizer Alpen. – Diplomarbeit an der Philosophisch-Naturwissenschaftlichen Fakultät der Universität Bern.

Address of the authors:
Conradin A. Burga & Stefan Bührer,
Dept. of Geography University of Zurich, Winterthurerstrasse 190, CH-8057 – Zurich (Switzerland).
Corresponding author: Conradin A. Burga, Email: conradin.burga@bluewin.ch