

Zeitschrift: Berichte des Geobotanischen Institutes der Eidg. Techn. Hochschule, Stiftung Rübel

Herausgeber: Geobotanisches Institut der Eidg. Techn. Hochschule, Stiftung Rübel

Band: 44 (1975-1976)

Artikel: Reproduction in natural triploid hybrids ($2n=24$) between *Cardamine rivularis* Schur and *C. amara* L.

Autor: Urbanska-Worytkiewicz, Krystyna

Kapitel: 5: Discussion

DOI: <https://doi.org/10.5169/seals-377685>

Nutzungsbedingungen

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

Conditions d'utilisation

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

Terms of use

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

Download PDF: 15.07.2025

ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>

obtained. We are inclined to think that the triploid offspring derived from polarized gametes R and RA functioning in a complementary way; on the other hand, the tetraploid plant might have been issued from the union of an unreduced RRA gamete and a polarized R one. The triploid hybrids from Urnerboden appear thus to breed true for their particular genomic constitution, bar the cases where unreduced gametes occasionally contribute to some new combinations. This unusual breeding behaviour might be double-controlled by a gametophytic and a zygotic selection, the latter mechanism comparable to the balanced lethals system operating in *Oenothera Lamarckiana* (Fig. 41). It seems therefore that several ordinarily deleterious mechanisms add up in the *Cardamine* hybrids to a system with high survival value in which plants are able not only to breed true but also to profit from maximum hybrid vigour and to multiply prolifically.

5. Discussion

The rarity of hybrids between *Cardamine rivularis* and *C. amara* in the wild apparently is a measure of an isolation occurring between the two species (URBANSKA-WORYTKIEWICZ and LANDOLT 1972). The present investigations revealed that internal barriers of the reproductive isolation play the main rôle, strong incompatibility blocks operating both at pre- and postmating stages.

Natural hybrids born from crosses at the homoploid level between sexual species usually have the same chromosome number as their parents, particularly in diploid taxa. The large triploid population at Urnerboden issued from the diploid parents represents thus an exceptional case. To some extent comparable are the peculiar "lolioid" and "festucoid" hybrids ($2n=21$, the genomic constitution LLF and FFL, respectively) between *Lolium perenne* ($2n=14$) and *Festuca pratensis* ($2n=14$), studied by a succession of authors (e.g. PETO 1934, JENKIN 1933, 1955, WIT 1959, 1963, 1964, WHITTINGTON and HILL 1961, ESSAD 1962, 1964, 1966, 1968, GYMER and WHITTINGTON 1973a, 1973b, 1975a, 1975b). A single triploid hybrid ($2n=33$) between *Primula*

veris ($2n=22$) and *P. elatior* ($2n=22$), apparently formed with a part of an unreduced gamete of the latter species, belongs also to this rare category (VALENTINE 1966). However, in the above mentioned cases both diploid and triploid hybrids occurred within the populations, whereas diploid hybrids of *Cardamine* have so far been sought unsuccessfully among the hundreds of triploids at Urnerboden.

Unreduced pollen grains were previously observed in *Cardamine rivularis* from various parts of its distribution range, including Urnerboden (URBANSKA-WORYTKIEWICZ and LANDOLT 1972, 1974, 1977). They proved to be functioning in some crosses performed in the course of the present study: two pentaploid individuals ($2n=40$, RRRRA) obtained in backcrosses to *C. rivularis* could only have been formed through the union of unreduced gametes, RRA and RR respectively. Therefore a possibility cannot be ruled out that triploid plants with a genomic constitution RRA might occasionally appear in natural populations as a direct result of crosses between *C. rivularis* and *C. amara*.

It is generally believed that the sterility of hybrids depends most frequently either upon their genic balance or chromosomal structure; interesting remarks in this subject were presented among others by REUSCH (1960), AHLÖWALIA (1965) as well as GYMER and WHITTINGTON (1975a) dealing with the triploid hybrids between *Lolium* and *Festuca*. A similar interpretation might apply to the *Cardamine* hybrids from Urnerboden: some rare triploids developed from crosses between *C. rivularis* and *C. amara* were more likely to contain a full series of complementary genes than their diploid siblings; it is also possible that small translocations and deficiencies that mainly account for chromosomal sterility might occur less frequently in triploids than in diploids. The particular genomic constitution of the 24chromosomal RRA hybrids might accordingly have conferred them some chance of reproduction and survival within the population whereas the diploid RA plants remained genetically passive and eventually disappeared.

The above presented hypothesis might explain an initial phase of development of the triploid hybrid population at Urnerboden; however, it is not very helpful when the characteristic abundance of the 24chromosomal plants with non-dehiscent anthers is being considered. To begin with, it is

rather difficult to accept a recurrent hybridization between the diploid *Cardamine rivularis* and *C. amara* always resulting solely in triploids. Secondly, sexually reproducing triploids of the F_1 generation should normally produce various intermediate, aneuploid segregates; however, all the 337 studied triploids have invariably represented an exactly euploid level and the same genomic constitution RRA, in spite of the fact that some slight morphological variation occurred and the rare pollen-producing individuals showed various degrees of the pollen fertility (26%-62%).

Observations on meiosis in the triploid hybrids as well as the results obtained in experimental crosses contribute to a better understanding of the unusual stabilization of the triploid hybrids from Urnerboden. Three different types of chromosome segregation were observed at I anaphase: 1/ a normal segregation 12 : 12 was rather infrequent; 2/ a random segregation, characteristic for the studied material and 3/ the most peculiar, polarized or preferential segregation i.e. $8_R 8_A$ vs 8_R rather frequently occurring both in anthers and ovules. The diversified meiosis followed by elimination of numerous micro- and macrospores and probably by a zygotic selection as well, proved to have a variety of effects upon the breeding behaviour.

An apparently normal sporogenesis should first be commented. It cannot be excluded that the triploid hybrids may sometimes segregate truly reduced viz. 12chromosomic micro- and macrospores. However, the functioning of such gametes seems rather doubtful given their unbalanced genomic constitution: they should carry one genome of *Cardamine rivularis* plus only a half the genome of *C. amara*. It should be emphasized that the results of our experimental crosses positively indicate three euploid gametic types i.e. R, RA and RRA functioning in the hybrids, no definite proof, however, has been obtained for the reduced, aneuploid gametes.

A random segregation during meiosis is a well-known feature of hybrids, often accounting for their reduced fertility and giving rise to aneuploid offspring in the F_2 . A noteworthy example represents the 35chromosomic hybrid between *Agrostis gigantea* ($2n=42$) and *A. tenuis* ($2n=28$): this low-fertile pentaploid forms 14 bivalents and 7 univalents, but an apparently random segregation results in aneuploid backcross- and F_2 -individuals, both in the wild as well as in experiments (STUCKEY and BANFIELD 1946, JONES

1956, WIDEN 1971). The random segregation mostly resulting in various abortive aneuploid spores in the *Cardamine* hybrids speaks well, on the one hand, for their status of interspecific hybrids; on the other hand, it represents an important evolutionary mechanism contributing to the gamete pool of hybrids, for it may lead to the formation of unreduced gametes. The autoallohexaploids ($2n=48$, RRRRAA) spontaneously formed at Urnerboden represent the best argument in favour of unreduced gametes functioning in triploid hybrids (URBANSKA-WORYTKIEWICZ and LANDOLT 1974, 1977, URBANSKA-WORYTKIEWICZ, in press).

Incidentally, balanced gametes of R and/or RA type might also be formed as a result of a random segregation. On this occasion, the 9chromosomic hybrid between *Hypocoeris radicata* ($2n=8$) and *H. glabra* ($2n=10$) should be mentioned. Viable gametes of this plant contain respectively four, five or rarely nine chromosomes; all these gametic types are functioning in ovules, as indicated by results of backcrosses to *H. radicata* (HOLMBERG 1930, SANDWITCH 1954, BENOIT 1959, PARKER 1971). In view of the fact that two classes of gametes viz. $n=4$ and $n=5$ correspond numerically to constituent genomes of the *Hypochoeris* hybrid, it would be very interesting to get still more data concerning mechanism of its segregation.

The polarized segregation occurring in triploid hybrids resulted in the formation of euploid gametes, respectively carrying a single genome of *C. rivularis* (R) and two genomes, one from either parent species (RA). The functioning of such gametes was confirmed in various experimental crosses.

Diploid and triploid backcross plants deserve a special attention, for they show striking affinities to the plants found in the wild. The 16-chromosomic RR plants resembled *Cardamine rivularis* in a spectacular way. The only distinct difference was their pronounced pollen sterility ranging with a single exception from 84 to 94 per cent, whereas a genuine *C. rivularis* produced on average only 13 per cent of abortive pollen. In view of these results, some highly sterile diploid plants of a *C. rivularis* type, recently found at Urnerboden are of a special interest (URBANSKA-WORYTKIEWICZ and LANDOLT 1977). Triploid backcross individuals, apparently resulting from polarized RA gametes of the hybrids fertilized by normal sperms of

C. rivularis corresponded exactly to the 24chromosomic plants predominating at Urnerboden, both in their morphology as well as the complete male-sterility.

Three tetraploids ($2n=32$, RRRA) obtained in the course of the present study apparently were formed with a part of unreduced gametes of the hybrids, fertilized either by normal sperms of *Cardamine rivularis* or polarized R gamete operating in the 24chromosomic plant. It is interesting to note that a single plant of the same kind was recently found at Urnerboden.

In conclusion, an attempt may be undertaken to explain the origin of plants forming the population at Urnerboden. It can be assumed that the rare triploids producing pollen in a frequency higher than 2-3%, represent the first hybrid generation i.e. a direct product of crosses between *Cardamine rivularis* and *C. amara*. On the other hand, hundreds of the male-sterile plants occurring at Urnerboden might correspond to further generations issued from backcrosses to *Cardamine rivularis* as well as the sexual reproduction of triploid hybrids themselves. The same could be said for the tetraploid RRRA plants, very seldom appearing within the population. Diploid plants of *C. rivularis* morphology might in turn represent not only the genuine parent taxon but also backcross individuals. The seed production in triploid plants is, admittedly, very limited, but might be partly compensated by the great total number of flowering shoots; recurrent backcrosses and allogamy of the hybrids might accordingly contribute to the development of the population, effects of the sexual reproduction with little or no segregation being reinforced by an extremely strong vegetative multiplication.

The two aspects of the reproduction of triploid hybrids apparently have a bearing upon the population structure. Demographical studies carried out at Urnerboden revealed a diversified density of population: some sectors situated within cut manured meadows were particularly dense, whereas hybrid stands within open pastures and drainage canals were much less compact (URBANSKA-WORYTKIEWICZ and LANDOLT, in press). Vegetative multiplication, promoted by the cutting of the meadows, apparently represents an optimal adaption of triploid hybrids to this biotope. Reproduction by seeds seems there rather difficult for two reasons: 1/ some meadows may be cut before the seed devel-

opment is completed; 2/ establishment of seedlings might anyway be problematic in some densely inhabited stands. On the contrary, open pastures offer more favourable conditions for seed setting and their dispersion, for 1/ grazing is not very intensive and 2/ light conditions are better for young plants. One might accordingly suppose that triploid hybrids use a different reproductive strategy in different ecological niches, vegetative multiplication being the only mechanism acting within some cut, manured meadows, whereas both sexual and vegetative reproduction are occurring within the pastures and drainage canals.

The question remains of what changes in the variation pattern might be expected within the population at Urnerboden. The reproductive behaviour of the triploid hybrids is characterized by an exceedingly reduced recombination potential. In this way, adaptively valuable properties of F_1 are not lost in later generations. On the other hand, it might be expected that a production of essentially new variants will be critically hampered in the long run. However, the 24chromosomic hybrids have already generated an apparently successful variant through doubling of the chromosome number: the autoallohexaploids ($2n=48$, RRRRAA), recently found at Urnerboden, are fertile, vigorous and actually expanding within the population. Further investigations in this most interesting subject are continued.

Summary

Reproduction of the triploid *Cardamine* hybrids from Urnerboden comprises 1/ strong vegetative multiplication and 2/ sexual reproduction characterized by an extremely reduced recombination potential. The two mechanisms add up to an unusual system in which adaptive properties of the first hybrid generation become stabilized, the plants being thus able to profit from maximum hybrid vigour. Structure of the population from Urnerboden as well as its possible evolutionary trends are discussed.

Résumé

Reproduction des hybrides triploïdes de *Cardamine* d'Urnerboden comprend 1/ multiplication végétative très importante et 2/ reproduction sexuée caractérisée par un potentiel de recombinaison très réduit. Il en résulte un système étonnant stabilisateur des propriétés adaptives de la première génération des hybrides, les plantes pouvant ainsi profiter d'une vigueur hybride maximale. Sont discutés la structure de la population d'Urnerboden et ses changements évolutifs possibles.

Zusammenfassung

Die Fortpflanzung der triploiden *Cardamine*-Bastarde vom Urnerboden umfasst: 1. eine sehr erfolgreiche vegetative Vermehrung und 2. eine sexuelle Fortpflanzung, die durch stark reduzierte Rekombinationsmöglichkeiten charakterisiert ist. Daraus ergibt sich ein erstaunlich stabiles System von adaptiven Merkmalen der ersten Bastardgeneration, die den Pflanzen ein ausserordentlich üppiges Wachstum erlaubt. Die Populationsstruktur der Pflanzen vom Urnerboden und deren Entwicklungsmöglichkeiten werden diskutiert.

References

- AHLOOWALIA, B. S., 1965: Cytogenetic studies on natural hybrids between ryegrass and meadow descue. Z. Vererb.-Lehre 97, 226 - 242.
- BENOIT, M. P., 1959: Two interesting botanical discoveries in Merionethshire. Nature Wales 5, 726 - 728.
- CLELAND, R.E., 1962: The cytogenetics of *Oenothera*. Adv. Gen. 11, 147 - 237.
- 1972: *Oenothera*: cytogenetics and Evolution. Academic Press.
- DARLINGTON, D. C., 1937: Recent advances in cytology. 2nd ed. Blackiston.
- DE VRIES, H., 1917: Halbmutanten und Zwillingsbastarde. Ber. Dtsch. Bot. Ges. 35, 128 - 135.
- and BOEDIJN, H., 1924: Die Gruppierung der Mutanten von *Oenothera Lamarckiana*. Ber. Dtsch. Bot. Ges. 42, 174 - 178.
- EMERSON, S., 1935: The genetic nature of De Vries' mutation in *Oenothera Lamarckiana*. Amer. Nat. 69, 545 - 559.
- ESSAD, S., 1962: Etude génétique et cytogénétique des espèces *Lolium perenne* L., *Festuca pratensis* Huds. et de leurs hybrides. Ann. Amél. Plantes 12, No hors sér. 103 p.
- 1964: Etude comparative des hybrides réciproques *Lolium perenne* L. x *Festuca pratensis* Huds. et de leur descendance. Ann. Amél. Plantes 14, 295 - 308.
- 1966: Recherches sur l'origine des hybrides naturels *Festuca lolia-cea* 2N et 3N par la morphologie et la cytogénétique comparatives. Ann. Amél. Plantes 16, 5 - 41.

- 1968: Morphologie, méiose et fertilités des hybrides triploïdes réalisés entre *Lolium perenne* L. et *Festuca pratensis* Huds. Comparaison avec *Festuca loliacea* Curt. Amél. Plantes 18, 275 - 286.
- FAGERLIND, F., 1940: Sind die *canina*-Rosen agamospermische Bastarde? Svensk Bot. Tidsk 34, 334 - 354.
- GATES, R. R., 1908: Further studies in the chromosomes of *Oenothera*. Science 27, 325 pp.
- GYMER, P. T. and WHITTINGTON, W. J., 1973a: Hybrids between *Lolium perenne* and *Festuca pratensis*. I. Crossing and incompatibility. N. Phytol. 72, 411 - 424.
- 1973 b: Hybrids between *Lolium perenne* and *Festuca pratensis*. II. Comparative morphology. N. Phytol. 72, 861 - 865.
- 1975a: Hybrids between *Lolium perenne* and *Festuca pratensis*. III. Meiosis and fertility. N. Phytol. 74, 295 - 306.
- 1975b: Hybrids between *Lolium perenne* and *Festuca pratensis*. IV. Cytological abnormalities. N. Phytol. 75, 259 - 267.
- HAGEN, C. W., 1950: A contribution to the cytogenetics of the genus *Oenothera* with special reference to certain forms from South America. Indiana Univ. Publ. Sci. Ser. 16, 305 - 348.
- HECHT, A., 1950: Cytogenetic studies of *Oenothera* subg. *Raimannia*. Indiana Univ. Publ. Sci. Ser. 16, 255 - 304.
- HOLMBERG, O. R., 1930: *Hypochoeris glabra* L. x *H. radicata* L. nova hybr. Bot. Not. 1930, 413 - 416.
- HURST, C. C., 1931: Embryo-sac formation in diploid and polyploid species of *Rosaceae*. Proc. Roy. Soc. B. 109, 126 - 248.
- JAMES, S. H., 1956: Complex hybridity of *Isotoma petraea*. I. The occurrence of interchange heterozygosity, autogamy and a balanced lethal system. Heredity 20, 341 - 353.
- 1970: Complex hybridity in *Isotoma petraea*. II. Components and operation of a possible evolutionary mechanism. Heredity 25, 53 - 78.
- JENKIN, T. J., 1933: Interspecific and intergeneric hybrids in herbage grasses. I. Initial crosses. J. Genet. 28, 205 - 264.
- 1955: Interspecific and intergeneric hybrids in herbage grasses. XVI. *Lolium perenne* and *Festuca pratensis* with references to *Festuca loliacea*. J. Gen. 53, 379 - 441.
- JONES, K., 1956: Species differentiation in *Agrostis*. 3. *A. gigantea* Roth and its hybrids with *A. tenuis* Sibth. and *A. stolonifera* L. J. Genet. 54, 394 - 399.
- LEWIS, H. P., RAVEN, P. H., VENKATESH, C. S. and WEDBERG, H. L., 1958: Observations on meiotic chromosomes in the *Onagraceae*. Aliso 4, 73 - 86.
- LEWIS, H. P. and SZWEYKOWSKI, J., 1964: The genus *Gayophytum* (*Onagraceae*). Brittonia 16, 343 - 391.
- LÖVKVIST, B., 1956: The *Cardamine pratensis* complex - outlines of its cytogenetics and taxonomy. Symb. Bot. Ups. 110, 231 pp.
- 1957: Experimental studies in *Cardamine amara*. Bot. Not. 110, 423-441.
- LUTZ, A. M., 1907: A preliminary note of the chromosomes of *Oenothera Lamarckiana* and one of its mutants. *O. gigas*. Science 26, 151 - 152.
- PARKER, J. S., 1971: The control of recombination. D. Phil. Thesis, Univ. Oxford.
- PETO, F. H., 1934: The cytology of certain intergeneric hybrids between *Festuca* and *Lolium*. J. Gen. 28, 113 - 156.

- RAVEN, H. P. and GREGORY, D. P., 1972: Observations on meiotic chromosomes in *Gaura* (*Onagraceae*). *Brittonia* 24, 71 - 86.
- RENNER, O., 1917: Artbastarde und Bastardarten in der Gattung *Oenothera*. *Ber. Dtsch. Bot. Ges.* 35, 21 - 26.
- 1925: Untersuchungen über die faktorielle Konstitution einiger komplexheterozygotischen *Oenotheren*. *Bibl. Genet.* 9, 1 - 168.
- 1933: Zur Kenntnis der Gigas- und Hemigigas-Typen bei *Oenothera*. *Flora* 128, 123 - 144.
- 1939: Kurze Mitteilungen über *Oenothera*. III. Ueber Gigas- und Hemigigas-Formen und ihre Verwendung zur Untersuchung des *cruciata*-Merkmals. *Flora* 33, 215 - 238.
- REUSCH, J. H. D., 1960: The effects of gamma radiation on crosses between *Lolium perenne* and *Festuca pratensis*. *Heredity*, London 14, 51 pp.
- SANDWITH, N. Y., 1954: A *Hypochoeris* hybrid. *Proc. Bot. Soc. B. I.* 1, 99 pp.
- SAX, K., 1931: Chromosome ring formation in *Rhoeo discolor*. *Cytologia* 3, 36 - 53.
- SMITH-WHITE, S., 1948: Polarized segregation in the pollen mother cells of a stable triploid. *Heredity* 2, 119 - 129.
- 1955: The life history and genetic system of *Leucopogon juniperinus*. *Heredity* 9, 79 - 91.
- 1959 b: Pollen development patterns in the *Epacridaceae*. *Proc. Linn. Soc. New South Wales* 84, 8 - 35.
- STEBBINS, G. L. and ELLERTON, S., 1939: Structural hybridity in *Paeonia californica* and *P. Brownii*. *J. Genet.* 38, 1 - 36.
- STUCKEY, I. H. and BANFIELD, W. G., 1946: The morphological variations and occurrence of aneuploids in some species of *Agrostis* in Rhode Island. *Amer. J. Bot.* 33, 185 - 190.
- TÄCKHOLM, G., 1922: Zytologische Studien über die Gattung *Rosa*. *Acta Horti Berg.* 7, 91 - 381.
- URBANSKA-WORYTKIEWICZ, K., 1976: Ségrégation polarisée chez les hybrides naturels triploïdes ($2n=24$) entre *Cardamine rivularis* Schur ($2n=16$) et *C. amara* ($2n=16$). *Bull. Soc. Bot. Fr.* (in press).
- 1977: An autoallohexaploid in *Cardamine* L., new to the Swiss flora. *Ber. Geobot. Inst. ETH, Stiftung Rübel*, 44, 86 - 103.
- and LANDOLT, E., 1972: Natürliche Bastarde zwischen *Cardamine amara* L. und *C. rivularis* Schur aus den Schweizer Alpen. *Ber. Geobot. Inst. ETH, Stiftung Rübel* 41, 88 - 101.
- 1974: Biosystematic investigations in *Cardamine pratensis* L. s. l. I. Diploid taxa from Central Europe and their fertility relationships. *Ber. Geobot. Inst. ETH, Stiftung Rübel* 42, 42 - 139.
- 1974 a: Hybridation naturelle entre *Cardamine rivularis* Schur et *C. amara* L., ses aspects cytologiques et écologiques. *Act. Soc. Helv. Sci. Nat.* 1974, 89 - 90.
- 1977: Recherches démographiques et écologiques sur une population hybridogène de *Cardamine* L. *Bull. Soc. Bot. Fr.* (in press).
- VALENTINE, D., 1966: The experimental taxonomy of some *Primula* species. *Trans. Bot. Soc. Edinb.* 40, 169 - 180.
- WALTERS, J. L., 1942: Distribution of structural hybrids in *Paeonia californica*. *Amer. J. Bot.* 29, 270 - 275.
- WHITTINGTON, W. J. and HILL, J., 1961: Growth studies on natural hybrids between *Lolium perenne* and *Festuca pratensis*. *J. Exp. Bot.* 12, 330 - 340.

- WIDÉN, K. G., 1971: The genus *Agrostis* L. in eastern Fennoscandia. Taxonomy and distribution. *Flora Fenn.* 5, 1 - 209.
- WIT, F., 1959: Hybrids of ryegrasses and meadow fescue and their value of grass breeding. *Euphytica* 8, 1 - 12.
- 1963: Natural experimental *Festulolium* hybrids and their derivatives. *Proc. Xth Int. Congr. Genet.* 1, 210 pp.
- 1964: Natural and experimental hybrids of ryegrass and meadow fescue. *Euphytica* 13, 294 - 304.

Address of the author: PD Dr. K. Urbanska-Worytkiewicz
Geobotanisches Institut ETH
Stiftung Rübel
Zürichbergstrasse 38
8044 Zürich