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## Scientific Works of Professor Giorgi (Gia) Nakhutsrishvili

### Abstract

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After a synthetic reconstruction of the history of exploration and studies on Caucasian flora, the authors list a selection of botanical works published by Professor Giorgi (Gia) Nakhutsrishvili dedicated mainly to the flora and vegetation of the Caucasus. There are 122 articles and monographs compared to more than 200 often published together with his students, in Georgian, Russian, English, German and French. Although over eighty years old, the scientific activity of Gia Nakhutsrishvili continues, today as before accompanied by the esteem and gratitude of the scientific community of his country and beyond.

*Key words:* Studies, Flora, Vegetation, Caucasus, Giorgi (Gia) Nakhutsrishvili, Georgia.

### Study of Flora and Vegetation of Georgia: history in brief

In 1745, the Georgian Prince Vakhushti Bagrationi (1696-1757) completed his fundamental work “Description of Kingdom of Georgia”. It is the first document dedicated particularly to the geography, nature and ethnography of Georgia, and which includes quite solid description and cartographic information on the country’s vegetation (the work was inscribed on UNESCO’s Memory of the World Register in 2013).

During the 18 and 19<sup>th</sup> centuries, famous Western European and Russian naturalists and botanists studied the flora of the Caucasus, including Georgia. Between 1700 and 1702, French and German botanists J. P. Tournefort (1656-1708) and A. Gundesheimer (1668-1715) travelled through Greece, Turkey, Armenia, and visited the Black Sea coast of Georgia, collecting plants and recording other observations. They were accompanied by the artist C. Aubriet (1651-1743), who sketched images of plant species. Later, in 1770, the eminent Swiss naturalist J. A. Gldenstdt (1745-1781) visited the Kazbegi region in the Great Caucasus and created the first collections of alpine plant species from that area.

Others who travelled via Caucasus and did their outstanding research mostly in 19<sup>th</sup> century include: F. A. F. Marschall von Bieberstein (1768-1826), C. C. Steven (1781-1863), K. H. E. Koch (1809-1879), F. J. Ruprecht (1814-1870), M. F. Adams (1780-1832),



Professor Gia Nakhutsrishvili during a field survey of aspects of Caucasian vegetation.

A. A. Musin-Pushkin (1760-1805), J. J. F. W. Parrot (1791-1841), N. A. Desulavi (1860-1933), A. Rehman (1840-1917), and G. F. R. Radde (1831-1903). G. Radde was the founder of the Caucasus Natural Historical Museum, the *Museum Caucasicum*, established in Tbilisi in 1867 (currently the Georgian National Museum), where, in the interim, an extensive herbarium collection of Caucasus plants has been created – exceptionally important from historical-botanical, biogeographical and biodiversity conservation viewpoints.

In 20<sup>th</sup> Century, important input in studies of plants of the Caucasus (including Georgia) has been made by A. A. Grossheim (1888-1948), Ya. S. Medwedew (1848-1923), N. A. Bush (1869-1941), and others. The first botanical survey of the Caucasus alpine plant communities were published by the British botanist W. Seifrizz in 1931.

A new phase in research of Georgian flora and vegetation started in 1933, when the Institute of Botany of the Georgian Academy of Sciences was established (today the Institute is functioning within the structure of Ilia State University). N. Ketskhoveri (1897-1982), A. G. Dolukhanov (1900-1992), M. Sakhokia (1902-1983), Sh. Nakhutsrishvili (1901-1980), A. Kharadze (1905-1977), I. P. Mandenova (1909-1995), A. Makashvili (1896-1962), A. Javakhishvili (1903-1976), and their colleagues made significant contributions to current knowledge, particularly in the field of typology of forest and herbaceous vegetation, their altitudinal and spatial distribution, and mapping. Somewhat earlier (1928), the first studies of alpine flora in the Kazbegi region (agro-botanical mapping, creation of herbarium, description of new species) were started and led by A. Kharadze. From 1937, she was assisted by the local resident botanist E. J. Khutsishvili.

The second active wave in the study of plants and plant communities of Georgia begins in 1960s. This stage, which has an ecological emphasis, was driven by Prof. Dr. Gia Nakhutsrishvili and members of his school (L. Abashidze, O. Abdaladze, D. Bedoshvili, T. Gamkrelidze, Z. Gamtsemlidze, M. Chiboshvili, A. Chkhikvadze, Z. Kikvidze, L. Khetsuriani, T. Kurdadze, G. Sanadiradze, S. Sikharulidze, N. Tulashvili, N. Zazanashvili), formed at the Kazbegi High-Mountain Ecological Station of the Institute of Botany,

Georgian Academy of Sciences (currently known as the Stephantsminda Alpine Ecology Institute, Ilia State University). Establishment of this station (under the direction of N. Ketskaveli and G. Nakhutsrishvili) in 1969 played a key role for development of research in this alpine area. Soon, the station and efforts of Georgian researchers, as well as regular study results, inspired and attracted scientists from other parts of the world. Consequently, the Kazbegi High Mountain Station became an international center for alpine ecology. Located at 1850 m above sea level, the station has for decades been a focal point of ecological studies of alpine plants and plant communities. At the end of the 1970s, Prof. Walter Larcher (Institute of Botany, University of Innsbruck), together with Prof. Gia Nakhutsrishvili, initiated experimental research in alpine plant ecology at this station. Field work was led by Prof. A. Cernusca and Prof. C. Körner.

Prof. G. Nakhutsrishvili's research always addresses actual problems and scientific questions from different fields of ecology of plants and plant communities; among them are plant and biotope diversity, phytosociology, plant adaptation strategies to the severe conditions, climate change and human impacts on vegetation, plants as a bioclimatic indicators, phenorhythm types of plants, comparative analysis of the Great Caucasus and the Alps vegetation, and the role of Colchic forest in the world's biogeographical classification. Prof. G. Nakhutsrishvili always seeks out modern methodologies and innovation in his work. He has established international long-term scientific cooperation with western colleagues (particularly the Institute of Botany, University of Innsbruck), even during the Soviet period, when it was extremely difficult because of the political and ideological barriers of that time.

Prof. G. Nakhutsrishvili is a corresponding member of the Georgian and Austrian Academies of Sciences; he is a President of Georgian Botanical Society, and a leader in the IUCN SSC Caucasus Plant Red List Authority.

Moreover, Prof. G. Nakhutsrishvili has for a long time (1982-2006) served the Institute of Botany as its director: notably during the hard times that occurred in the 1990s, after the dissolution of the Soviet Union. In that time in Georgia, the country with its recently restored independence, experienced a backdrop of political violations, wars and instability, the economy in fact collapsed, and governmental funding allocated for research dramatically decreased. Despite such hard conditions, thanks to Prof. G. Nakhutsrishvili's great effort, the Institute of Botany, and botanical research in general, somehow survived.

The number of scientific publications of Prof. Gia Nakhutsrishvili exceeds 200. In this publication, we have selected part of them (totally 122 titles), which are included in the list below.

### **Concluding remarks**

The exploration and studies on the flora and vegetation of the South Caucasus are briefly retraced. Their beginning dates back to the first half of the 18th century. Studies have intensified particularly since the second half of the 19th century with the contribution of various European scholars. During the Soviet time, external input had severe limitations and the studies were developed by Soviet Union botanists. In the first half of the 1900s, studies on vegetation began which in Georgia will be intensified after the break of the

Soviet Union, together with the reorganization of the country's botanical institutions. In this process, a fundamental contribution is made by Professor Prof. G. Nakhutsrishvili at the Institute of Botany of Ilia State University in Tbilisi. Indeed, his studies – already published in English – will make the vegetation of the Georgian Caucasus known to the international scientific society. Of the more than 200 articles and monographs published by Prof. G. Nakhutsrishvili, often together with his students and collaborators, 122 deserve special mention. They are precisely those listed in our contribution. In all the long and often burdensome work carried out by Prof. G. Nakhutsrishvili, he never lost the esteem and gratitude of the scientific society of his country as well as the appreciation of the international community. The scientific work of the magister Gia Nakhutsrishvili continues to this day, demonstration of this are the two articles (Nakhutsrishvili & al. 2021; Tephnadze-Hoernchen & al. 2021) hosted in this volume of *Boccone* dedicated to him for his 85th birthday.

## Bibliography

### *Diversity of Plant species & communities*

- Abdaladze, O., Gobejishvili, R., Nakhutsrishvili, G. & Neidze, V. 1998: Khevi. – Tbilisi: 48 [in Georgian].
- Agladze, G., Eliava, I., Komakhidze, A., Mazmanidi, N., Nakhutsrishvili, G. & Naskidashvili, P. 1998: Biological Diversity of the Black Sea basin area: It's current state. – Pp. 1-15 in: Conservation of the Biological Diversity as a Pre-requisite for Sustainable Development in the Black Sea Region. – NATO ASI Series 2, Environment, **46**. – Dordrecht, Boston, London.
- Akhalkatsi, M., Ekhvaia, J., Mosulishvili, M., Nakhutsrishvili, G. & Abdaladze, O. 2010: Erosion of Crop Genetic Diversity in Mountainous Regions of Georgia. – In: Spehn, E. M., Rudmann-Maurer, K., Körner, Ch. & Maselli, D. (eds): Mountain Biodiversity and Global Change. – Basel.
- , —, —, —, — & Batsatsashvili, K. 2010: Reasons and processes leading to the erosion of crop genetic diversity in mountainous regions of Georgia. – *Mount. Res. Develop.* **30(3)**: 304-310.
- Hübl, E., Nakhutsrishvili, G. & Scharfetter, E. 2010: Der weidewald des Alpengartens von Bakuriani (Georgien). – *Verh. Zool.-Bot. Ges. Österreich* **147**: 98-108.
- Nakhutsrishvili, G. 1990: General physical and geobotanical characteristics. – Pp. 5-15 in: Nakhutsrishvili, G. (ed.) Ecological and Geobotanical Studies at the Kazbegi High-Mount Station. – Tbilisi.
- 1996: Pflanzenleben in der subnivalen Stufe des Kaukasus. – Pp. 373-385 in: *Colloques phytosociologiques XXIV, Fitodinamica*. – Berlin, Stuttgart.
- 1998a: The Vegetation of the Subnival Belt of the Caucasus. – *Arctic Antarctic Alpine Res.* **30(3)**: 222-226.
- 1998b: Hohgebirgsvegetation Georgiens (Kaukasus). – Pp. 93-100 in: Nakhutsrishvili, G. & Abdaladze, O. (eds) Plant life in high mountains. – *Georg. Acad. Sci. Inst. Bot.* Tbilisi.
- 1999a: The vegetation of Georgia (Caucasus) – *Braun-Blanquetia* **15**: 74.
- 1999b: Evergreen broad-leaved vegetation in the Colchis. – Pp. 167-179 in: Kloetzli, F. & Birkhaeuser, G. R. W. (eds) Recent shifts in vegetation boundaries of deciduous forests, especially due to general global warming. – Basel, Boston, Berlin.
- 2000: Basic biomes of Georgia. – Pp. 43-68 in: Beruchashvili, N., Kushlin, A. & Zazanashvili, N. (eds) Georgia's biological and landscape diversity. – Tbilisi.

- 2002: Kaukasus und Alpen: Ein Vergleich der Vegetation. – Pp. 82-87 in: *Forum Alpinum 2002/ the Nature of Alps*, Alpbach.
- 2003a: High mountain vegetation of the Caucasus region. – Pp. 93-103 in: Nagy, L., Grabherr, G., Körner, C. & Thompson, D. B. A. (eds) *Alpine biodiversity in Europe*. – Berlin, Heidelberg.
- 2003b: Caucasus and Alps: vegetation comparison. – P. 75 in: *Palmarum Hortus Francofurtensis*, 7. – Frankfurt.
- 2004a: Kaukasus. – Pp. 124-134 in: Burga, A., Klötzli, F. & Grabherr, G. (eds) *Gebirge der Erde (Landschaft, Klima, Pflanzenwelt)*. – Stuttgart.
- 2004b: Die postglaziale Vegetation des Kaukasus. – *Coll. Phytosociol.* **27**: 187-197.
- 2011a: Historique de l'Institut de Botanique de Géorgie. – *Ethnopharmacol.* **47**: 39-44.
- 2011b: The Central Caucasus vegetation diversity, database creation and management. – Pp. 133-134 in: Nakhutsrishvili, G. (ed.) *Biodiversity of Georgia*. – Tbilisi [in Georgian with English summary].
- 2013: The vegetation of Georgia (South Caucasus). – Heidelberg, New York, Dordrecht, London.
- & Abdaladze, O. 2017a: Vegetation of the Central Great Caucasus along W-E and N-S transects. – Pp. 11-16 in: Nakhutsrishvili, G., Abdaladze, O., Batsatsashvili, K., Spehn, E. & Körner, Ch. (eds) *Plant Diversity in the Central Great Caucasus: A Quantitative Assessment. Geobotany Studies: Basics, Methods and Case Studies*. – Cham.
- & — 2017b: Plant diversity of the Central Great Caucasus. – Pp. 17-111 in: Nakhutsrishvili, G., Abdaladze, O., Batsatsashvili, K., Spehn, E. & Körner, Ch. (eds) *Plant Diversity in the Central Great Caucasus: A Quantitative Assessment. Geobotany Studies: Basics, Methods and Case Studies*. – Cham.
- & Gagnidze, R. 1999: Die subnivale und nivale hochgebirgsvegetation des Kaukasus. – *Phytocoenosis* **11**: 173-182.
- & Ozenda, P. 1998: Aspect Géobotaniques de la Haute Montagne dans le Caucase. – *Essai Comparaison Alpes Ecol.* **29**: 139-144.
- , Abdaladze, O. & Akhalkatsi, M. 2004: Concerning the tree line vegetation of the Kazbegi region (the Central Caucasus). – *Bull. Georg. Acad. sci.* **169(1)**: 122-125.
- , — & — 2006: Biotope types of the treeline of the Central Greater Caucasus. – Pp. 211-225 in: Gafta, D. & Akeroyd, J. (eds) *Nature conservation: concepts and practice*. – Berlin.
- , — & Kikodze, A. 2005: Khevi: Kazbegi region. – Tbilisi.
- , Akhalkatsi, M. & Abdaladze, O. 2009: Main treats to the mountain biodiversity in Georgia (the Caucasus). – *Mountain Forum Biull.* **9(2)**: 18-19.
- , Sikharulidze, Sh. & Abdaladze, O. 2006: Bakuriani – Natural and Cultural Resources of the Borjomi region. – Tbilisi.
- , Zazanashvili, N. & Batsatsashvili, K. 2011: Regional profile: Colchic and Hyrcanic temperate rainforest of the Western Eurasian Caucasus. – Pp. 214-221 in: Della Sala, D. A. (ed.) *Temperate and boreal rainforest of the World: Ecology and Conservation*. – Washington, Covelo, London.
- , —, — & Montalvo, C. S. 2015: Colchic and Hyrcanian forests of the Caucasus: similarities, differences and conservation status. – *Fl. Medit* **25(Special Issue)**: 185-192. <http://dx.doi.org/10.7320/FlMedit25SI.185>
- , Abdaladze, O., Akhalkatsi, M., Batsatsashvili, K. & Sharikadze, Kh. 2010: Alpine plant diversity and function in the Central Caucasus. – *Chandolin*.
- , Grigalashvili, N., Mtskhvetadze, J., Chelidze, D. & Sikharulidze, Sh. 2009: Checklist of the flora of Bakuriani-Tskhratskaro. – Tbilisi.
- , Batsatsashvili, K., Gagnidze, R., Shetekauri, Sh., Manvelidze, Z., Memiadze, N., Kharazishvili, D. 2013: Georgia. – Pp. 113-147 in: Solomon, J., Shulkina, T. & Schatz, G. (eds) *Red List of*

the Endemic Plants of the Caucasus: Armenia, Azerbaijan, Georgia, Iran, Russia, and Turkey. – Monographs in Systematic Botany from the Missouri Botanical Garden, **125**. – Saint Louis.

*Biology & ecology of plants*

- Abashidze, L. & Nakhutsrishvili, G. 1990: Cenopopulations of plants. – Pp. 22-24 in: Nakhutsrishvili, G. (ed) Ecological and Geobotanical Studies at the Kazbegi High-Mount Station. – Tbilisi.
- Abdaladze, O., Nakhutsrishvili, G., Akhalkatsi, M. & Smith, W. K. 2005: Treeline Ecotone Structure and Some Ecological Features of *Betula litwinowii* in the Central Greater Caucasus. – Proc. Georgian Acad. Sci. Biol., Ser. B, **3(2)**: 57-65.
- Akhalkatsi, M., Abdaladze, O., Nakhutsrishvili, G. & Smith, W. K. 2006: Facilitation of Seedling microsites by *Rhododendron caucasicum* Extends the *Betula litwinowii* Alpine Treeline, Caucasus Mountains, Republic of Georgia. – Arctic, Antarctic & Alpine Res. **38(4)**: 481-488.
- Cernusca, A. & Nakhutsrishvili, G. 1983: Untersuchung der ökologischer auswirkungen. – Gess. Ökol., Bd. **10(1981)**: 183-192.
- Kikvidze, Z. & Nakhutsrishvili, G. 1998: Facilitation in the subnival vegetation patches. – J. Veg. Sci. **9**: 222-226.
- Kreeb, K.-H., Nakhutsrishvili, G., Weinmann-Kreeb, R.-M., Lühmann, H.-J., Wietschorke, G. & Kurdadze, T. 1990: Zur ökologischen Resistenz von Hohgebirgspflanzen des Zentralkaukasus in Abhängigkeit von der Höhenstufe. Aus den Sitzungsherichten der Österr. – Akademie der Wiss. Mathem.-naturw. Kl., **I, 198, 1, bis 4**: 82-110.
- Larcher, W. & Nakhutsrishvili, G. 1982: On pheno- and throphorhyrhmotypes of high mountain plants. – Ekologia **4**: 13-20 [in Russian].
- Nakhutsrishvili, G. 1959: Seasonal dynamics of subalpine meadows in the Lagodekhi State Nature Reserve. – Bull Georg Acad Sci **23(6)**: 1-4 [in Georgian].
- 1961: Seasonal dynamics of *Agrostidetum trifoliosum* in the Lagodekhi State Nature Reserve. – Bull Georg Acad Sci **25(1)**: 53-58 [in Russian].
- 1964: Study of aspects of high mountain meadows in the Kazbegi environs. – Transac. Tbilisi Inst. Bot. **23**: 101-111 [in Georgian].
- 1965a: Dynamics of seasonal development of some associations of subalpine meadows in the Lagodekhi State Nature Reserve. – Transac. Tbilisi Inst. Bot. **23**: 77-94 [in Georgian].
- 1965b: On the ecology of meadow vegetation in subalpine belt of the Central Caucasus. – Bull. Georg. Acad. Sci. **42**: 441-445 [in Russian].
- 1965c: On the some results of ecological-physiological investigations at the Kazbegi station. – Pp. 105-121 in: Ketskhoveli, N. (ed.) Biocoenology and phytocoenology. – Tbilisi [in Russian].
- 1965d: Some points of ecological study of high mountain vegetation of Georgia. – Probl. Bot. **7**: 213-218 [in Russian].
- 1967: Short ecological-physiological and phytocoenotic characteristics of some edifiers of subalpine vegetation in the Central Caucasus. – Bot. J. **53(12)**: 1635-1638 [in Russian].
- 1971: Ecology of high mountain herbaceous plants and plant communities of the Central Caucasus (water regime). – Tbilisi [in Russian with German summary].
- 1972: On the some ecological-phytocoenological research conducted at Kazbegi High Mountain Station. – Bull. Georg. Bot. Soc. **1972**: 55-69 [in Georgian].
- 1974a: Ecology of high mountain herbaceous plants and plant communities of the Central Caucasus (Rhythm of development, photosynthesis, ecobiomorhes). – Tbilisi [in Russian].
- 1974b: Status of ecological studies of high mountain vegetation. – Bot. J. **59(5)**: 731-741, [in Russian].



- 1975: Ökologische Untersuchungen auf der Hohgebirgsstation von Kasbegi – Tbilisi.
- 1976: Ecological studies on the Kazbegi high mountain station. – *Ecologia* **3**: 81-85 [in Russian].
- 1977a: Ecological research in pessimal conditions of high mountains of the Caucasus. – Pp. 27-29 in: Nakhutsrishvili, G. (ed.) High Mountain Ecosystem of Kazbegi. Moscow–Tbilisi [in Russian].
- 1977b: Biogeocoenotic research at the Kazbegi high mountain station. – Pp. 30-39 in: Nakhutsrishvili, G. (ed.) The high mount ecoystems of Kazbegi. – Tbilisi [in Russian].
- 1977c: Status of alpine ecosystems research and ecological studies in the Kazbegi. – Pp. 57-62 in: Nakhutsrishvili, G. (ed.) The high mount ecoystems of Kazbegi. – Tbilisi [in Russian].
- 1979: Status of the studies of high mountain ecosystems. – *Probl. Bot.* **14(2)**: 5-11 [in Russian].
- 1982a: Resumes of ecological studies in high-mountains of Georgia. – *Bull. Mosc. Soc. Nat. Explor.* **87(6)**: 12-22 [in Russian].
- 1982b: Status of alpine ecosystems study. – *Probl. Bot.* **14(2)**: 6-11 [in Russian].
- 1985: On the structural-functional organization of some ecosystems of the Central Caucasus. – Pp. 193-198 in: *Vegetation cover in high mountains*. Nauka, Moscow-Leningrad [in Russian].
- 1990: Life forms. – Pp. 15-17 in Nakhutsrishvili, G. (ed.) *Ecological and Geobotanical Studies at the Kazbegi High-Mount Station*. – Tbilisi.
- & Abashidze, L. 1998: Coenopopulations of plants in high-mountainous Kazbegi (Central Caucasus). – Pp. 101-111 in: Nakhutsrishvili, G. & Abdaladze, O. (eds) *Plant life in high mountains*. – Tbilisi.
- & Batsatsashvili, K. 2017: Quantitive analysis of the phytosociological releves. – Pp. 113-131 in: Nakhutsrishvili, G., Abdaladze, O., Batsatsashvili, K., Spehn, E. & Körner, Ch. (eds) *Plant Diversity in the Central Great Caucasus: A Quantitative Assessment*. Geobotany Studies: Basics, Methods and Case Studies. – Cham.
- & Chkhikvadze, A. 1974: On the biological productivity of high mountain herbaceous vegetation of the Central Caucasus. – *Bull. Georg. Acad. Sci.* **74(1)**: 65-168 [in Russian with English summary].
- & Gamtsemidze, Z. 1984: Plant life in extremal environment of the high mountains. – Leningrad [in Russian].
- & Körner, Ch. 1982: On the water regime of subalpine meadows of the Central Caucasus. – *Reports USSR Acad. Sci.* **2b(1)**: 243-245 [in Russian].
- , Abdaladze, O. & Sikharulidze, Sh. 1988: Alpine plant function in winter. – Pp. 201-215 in: Nakhutsrishvili, G. (ed.) *Alpine Ecology*. – Tbilisi [in Russian with English summary].
- , Cernusca, A., Dekker, P. & Khetsuriani, L. 1987: Photosynthesis and evaporation of phytocoenoses in the alpine belt. – Pp. 66-77 in: Rabotnov, T. (ed.) *Ecological studies of high mountain grasslands in Kazbegi*. – Tbilisi [in Russian with German summary].
- , —, Jussel, U. & Seeber, M. 1987: On the decomposition of plant materials in the Caricetum. – Pp. 77-82 in: Rabotnov, T. (ed.) *Ecological studies of high mountain grasslands in Kazbegi*. – Tbilisi [in Russian with German summary].
- , —, Mayer, R. & Tulashvili, N. 1987: Diffusion conductance and leaf water potential in two alpine grasslands. – Pp. 90-99 in: Rabotnov, T. (ed.) *Ecological studies of high mountain grasslands in Kazbegi*. – Tbilisi [in Russian with German summary].
- , —, Neuwinger, J. & Weiser, G. 1987: Soil study of two phytocoenoses in the Central Caucasus alpine belt. – Pp. 82-90 in: Rabotnov, T. (ed.) *Ecological studies of high mountain grasslands in Kazbegi*. – Tbilisi [in Russian with German summary].
- , —, Seeber, M. & Abashidze, L. 1987: Structure of phytocoenoses, microclimate and energy change of two grass ecosystems of alpine belt. – Pp. 44-50 in: Rabotnov, T. (ed.) *Ecological studies of high mountain grasslands in Kazbegi*. – Tbilisi [in Russian with German summary].
- , —, Wieser, G. & Chkhikvadze, A. 1987: Studies of water change of two herbaceous ecosystems in the alpine belt. – Pp. 50-66 in: Rabotnov, T. (ed.) *Ecological studies of high mountain grasslands in Kazbegi*. – Tbilisi [in Russian with German summary].

- , Gamkrelidze, T. A., Gamtsemlidze, Z. G., Sanadiradze, G. .M. 1990: Zur Frage der Überlebensstrategien von Pflancen in der subnivalen Stufe des Kaukasus. – *Giorn. Bot. Ital.* **124**: 781-791.
- , Abdaladze, O., Gamkrelidze, T., Sanadiradze, G. & Sikharulidze, Sh. 1988: Alpine Plant Activity in Winter. Scientific Meeting of Botanical Society of USSR – Actual Questions Botany in the USSR. – Nauka [in Russian].
- , Batsatsashvili, K., Rudman-Maurer, K., Körner, Ch., Spehn, E. 2017: New indicator values for Central Caucasus flora. – Pp. 145-160 in: Nakhutsrishvili, G., Abdaladze, O., Batsatsashvili, K., Spehn, E. & Körner, Ch. (eds) *Plant Diversity in the Central Great Caucasus: A Quantitative Assessment. Geobotany Studies: Basics, Methods and Case Studies.* – Cham.

*Human impacts & plant communities*

- Caprez, R., Spehn, E., Nakhutsrishvili, G. & Körner, Ch. 2012: Drought at erosion edges selects for a ‘hidden’ keystone species. – *Pl. Ecol. Div.* **4(4)**: 303-311.
- Körner, Ch. & Nakhutsrishvili, G. 1987: Influence of grazing on the water change of vegetation. – Pp. 99-120 in: Rabotnov, T. (ed.) *Ecological studies of high mountain grasslands in Kazbegi.* – Tbilisi [in Russian with German summary].
- , —, Spehn, E. M. 2006: High-elevation land use, biodiversity and ecosystem functioning. – Pp. 3-22 in: Spehn, E. M, Liberman, M. & Körner, Ch. (eds): *Land Use Change and Mountain Biodiversity.* – Boca Raton.
- , Spehn, E. M. & Nakhutsrishvili, G. 2004: Grazing the highlands: food, biodiversity and catchment implications. – In: Lüscher, A., Jeangros, B., Kessler, W., Hugunin, O., Lobsiger, M., Millar, N. & Suter, D. (eds) *Land Use Systems in Grassland Dominated Regions. Proc. of the 20<sup>th</sup> General Meeting of the European Grassland Federation, Luzern, Switzerland, 21-24 June.* – *Grassland Science in Europe* **9**: 278-280.
- Nakhutsrishvili, G. 1988: Ecological characteristic of the meadow vegetation of high mountains (on the example of Kazbegi, the Central Caucasus). – Pp. 175-200 in: Nakhutsrishvili, G. (ed.) *The Ecology of High Mountains.* – Tbilisi [in Russian with English summary].
- 1990: Ecological analysis of the influence of human impact over high-mountain meadows of the Caucasus. – *Ekologia* **3**: 3-7 [in Russian].
- 1998: Ecological and Phytosociological Studies of Vegetation alongside the Oil Pipeline in Saguramo State Reserve. – *Bull. Georg. Acad. Sci.* **158(3)**: 420-424.
- & Cernusca, A. 1982a: Peculiarities of phytoclimate, solar radiation and temperature rate of two ecosystems of the alpine belt of the Central Caucasus. – *Proc. Georg. Acad. Sci., ser Biol.*, **8(4)**: 272-275 [in Russian with English summary].
- & — 1982b: Ecological analysis of influence of pasturing on high-mountain meadows of the Central Caucasus. – *Reports USSR Acad Sci* **267**: 503-505 [in Russian].
- & — 1987: Influence of grazing on the structure, microclimate and energy change of phytocoenoses. – Pp. 17-43 in: Rabotnov, T. (ed.) *Ecological studies of high mountain grasslands in Kazbegi.* – Tbilisi [in Russian with German summary].
- , Chkhikvadze, A. & Khetsuriani, L. 1980: Productivity of alpine herbaceous communities in the Central Caucasus. – Tbilisi [in Russian].
- , Khetsuriani, L. & Tulashvili, N. 1982: Anthropogenic impact on ecophysiological peculiarities of alpine plants. – *Bull. Acad. Sci. Georgia* **105(1)**: 121-123 [in Russian with English summary].
- Sharikadze, Kh., Nakhutsrishvili, G., Akhlkatsi, M. & Abdaladze, O. 2011: Species Diversity of Eroded Slopes in the Kazbegi Region. – Pp. 29-32 in: Nakhutsrishvili, G. (ed.) *Biodiversity of Georgia.* – Tbilisi [in Georgian with English summary].



- Tappeiner, U., Cernusca, A. & Nakhutsrishvili, G. 1989: Bestandesstruktur und lichtklima ausgewählter Pflanzenbesände der subalpinen Stufe des Zentralkaukasus. Sitzungsber. – Österr. Akad. Wiss. (Wien), Mat. Nat. Wiss. **197**: 395-421.
- Tepnadze, N., Abdaladze, O., Nakhutsrishvili, G., Simmering, D., Waldhardt, R. & Otte, A. 2014: The impacts of management and site conditions on the phytodiversity of the upper montane and subalpine belts in the Central Greater Caucasus. – *Phytocoenologia* **44(3-4)**: 255-291.

#### *Vegetation zonation & mapping*

- Bohn, U., Zazanashvili, N. & Nakhutsrishvili, G. 2007: The map of the Natural vegetation of Europe and its application in the Caucasus Ecoregion. – *Bull. Georg. Acad. Sci.* **175(1)**: 112-121.
- Box, E. O., Fujivara, K., Nakhutsrishvili, G., Zazanashvili, N., Liebermann, R. J. & Miyawaki, A. 2000: Vegetation and landscapes of Georgia (Caucasus), as a basis for landscape restoration. – *Bull. Inst. Environ. Sci. Technol. Yokohama Nat. Univ.* **26(1)**: 69-102.
- Doluchanov, G. & Nakhutsrishvili, G. 2003: Die natürlichen Vegetationsformationen Europas und ihre Untergliederung. Hygrophile thermophytische Laubmischwälder. – Pp. 384-388 in: Bohn, U., Gollub, G. & Hettwer, Ch. (eds): Karte der natürlichen Vegetation Europas. Map of the Natural Vegetation of Europe, Maßstab/Scale 1:2,500,000. – Bonn.
- , —, Zazanashvili, N. & Ivanishvili, M. 2000: Sheet 9: Southeast Europe. – In: Bohn, U., Gollub, G., Hettwer, Ch., Neuhäuslova, Z., Raus, T., Schlüter, H. & Weber, H. (zusammengestellt und bearbeiteter) Karte der natürlichen Vegetation Europas. Map of the Natural Vegetation of Europe. Maßstab/Scale 1:2,500,000. – Bonn.
- Gribova, S., Nakhutsrishvili, G., Dolukhanov, A. & Neuhäusl, R. 1988: The high mountain vegetation on geobotanical map of the CEC-Member European countries. – Pp. 131-138 in: Nakhutsrishvili, G. (ed.) *The Ecology of High Mountains*. – Tbilisi [in Russian with English summary].
- Heiselmayer, P., Elvebakk, A. & Nakhutsrishvili, G. 2003: Polarwüsten und subnivale-nivale Vegetation der Hochgebirge. – Pp. 105-114 in: Bohn, U., Gollub, G., Hettwer, Ch., Neuhäuslova, Z., Raus, T., Schlüter, H. & Weber, H. (zusammengestellter und bearbeiteter) Karte der natürlichen Vegetation Europas. – Bonn.
- Nakhutsrishvili, G. 2005: Gliederung der Hohgebirgsvegetation des Kaukasus (im Vergleich zu den Alpen). – Pp. 335-345 in: Böhn, U., Hettwer, C. & Gollub, G. (eds): *Anwendung und Auswertung der Karte der natürlichen Vegetation Europas*. – Bonn.
- 2011: La vegetation des zones de haut montagne du Caucase. – *Ethnopharmacologia* **47**: 45-51.
- Zazanashvili, N., Gagnidze, R. & Nakhutsrishvili, G. 1995: High mountain vegetation on the new vegetation map of Georgia. – *J. Veg. Sci.* **6**: 157-158.
- , — & — 2000a: Main types of vegetation zonation on the mountains of the Caucasus. – *Acta Phytogeogr. Succ.* **85**: 7-16.
- , — & — 2000b: Small-scale mapping of high mountain vegetation of Georgia. – *Bull. Georg. Acad. Sci.* **161(2)**: 292-296.

#### *Climate change & vegetation*

- Abdaladze, O., Nakhutsrishvili, G., Batsatsashvili, K., Gigauri, K., Jolokhava, T. & Mikeladze, G. 2015: Sensitive alpine plant communities to the global environmental changes (Kazbegi region, the Central Great Caucasus). – *Amer. J. Environ Prot.* **4(3-1)**: 93-100.
- Erschbamer, B., Mallaun, M., Unterluggauer, P., Abdaladze, O., Akhalkatsi, M. & Nakhutsrishvili, G. 2010: Plant Diversity Along Altitudinal Gradients in the Central Alps

- (South Tyrol, Italy) and in the Central Greater Caucasus (Kazbegi Region, Georgia). – *Tuexenia* **30**: 11-29.
- , —, —, Nakhutsrishvili, G., Akhalkatsi, M. & Abdaladze, O. 2013: Plant diversity along altitudinal gradients in the Central Alps and in the Central Caucasus: The project GLORIA in south Tyrol (Italy) and in the Kazbegi region (Georgia). – Pp. 167-188 in: Pedrotti, F. (ed.): *Colloques Phytosociol.* **29**. – Camerino.
- Gigauri, K., Abdaladze, O., Nakhutsrishvili, G. & Akhalkatsi, M. 2014: Vascular plant diversity and climate change in the alpine zone of the Central Greater Caucasus. – *Intern. J. Ecosyst. Ecol. Sci.* **4(4)**: 573-589
- , Akhalkatsi, M., Abdaladze, O. & Nakhutsrishvili, G. 2016: Alpine plant distribution and thermic vegetation indicator on GLORIA summits in the Central Greater Caucasus. – *Pakistan J. Bot.* **48(5)**: 1893-1902.
- , —, Nakhutsrishvili, G. & Abdaladze, O. 2011: First Signs of Weak Thermophilisation on the GLORIA-EUROPE Target Region in the Central Caucasus (GE-SAK). – Pp. 19-22 in: Nakhutsrishvili, G. (ed.): *Biodiversity of Georgia*. – Tbilisi [in Georgian with English summary].
- , —, — & — 2013: Monitoring of vascular plant diversity in a changing climate in the alpine zone of the Central Caucasus. – *Turkish J. Bot.* **37(6)**: 1104-1114.
- Gottfried, M., Pauli, H., Futschik, A., Akhalkatsi, M., Barancok, P., Benito Alonso, J. L., Coldea, G., Dick, J., Erschbamer, B., Fernández Calzado, M. R., Kazakis, G., Krajci, J., Larsson, P., Mallaun, M., Michelsen, O., Moiseev, D., Moiseev, P., Molau, U., Merzouki, A., Nagy, L., Nakhutsrishvili, G., Pedersen, B., Pelino, G., Puscas, M., Rossi, G., Stanisci, A., Theurillat, J.-P., Tomaselli, M., Randin, Ch. F., Pellisier, L., Guisan, A. & Nakhutsrishvili, G. (2017d): A comparison of climate niches of the same alpine plant species in the Central Caucasus and the Alps. – Pp. 133-144 in: Nakhutsrishvili, G., Abdaladze, O., Batsatsashvili, K., Spehn, E. & Körner, Ch. (eds): *Plant Diversity in the Central Great Caucasus: A Quantitative Assessment*. – *Geobotany Studies: Basics, Methods and Case Studies*. – Cham.
- Nakhutsrishvili, G., Abdaladze, O. & Akhalkatsi, M. 2004: Global warming and treeline. – *Proc. Acad. Sci. Biol., Ser B*, **2(3-4)**: 87-90.
- , Akhalkatsi, M. & Abdaladze, O. 2013: First signs of transformation of alpine vegetation in the Caucasus as a result of climate warming (on the example of Kazbegi region). – Pp. 405-414 in: Pedrotti, F. (ed.) *Colloques Phytosociol.* **29**. – Camerino.
- , Abdaladze, O., Zazanashvili, N., Gamkrelidze, T. & Chiboshvili, M. 1999a: Excepted transformation of high-mountain vegetation of the Caucasus in connection with possible global climate change. – Pp. 77-88 in: Gzirishvili, T. & Beritashvili, B. (eds): *Georgia's Initial National Communication Under the UN framework Convention on Climate Change*. – Tbilisi.
- , —, —, — & — 1999b: Vulnerability of natural ecosystems. – Pp. 99-108 in: Beritashvili, B. & Janelidze, P. (eds): *Georgia's Initial National Communication Under the UN Framework Convention on Climate Change*. UNDP/GEF-Government of Georgia, Project GEO/96/G31, Tbilisi.
- , —, —, — & — 1999c: Caucasian Alpine Vegetation Transformation in Connection with Climate Global Change. – Pp. 87-100 in: *Climate Change National Bulletin of UN Framework Convention*, 8, Tbilisi [(in Georgian)].
- Villar, L., Vittoz, P., Vogiatzakis, I. & Grabherr, G. 2012: Continent-wide response of mountain vegetation to climate change. – *Nat. Clim. Chang.* **2(2)**: 111-115.

*Tutorial*

- Eliava, I., Nakhutsrishvili, G. & Kadjaia, G. 1992: Introduction to ecology, 1<sup>nd</sup> ed. – Tbilisi [in Georgian].
- , — & — 2009: Introduction to ecology, 2<sup>nd</sup> ed. – Tbilisi: [in Georgian].
- , — & — 2018: Ecology, 3<sup>rd</sup> ed. – Tbilisi (*in press*) [in Georgian].

*Popular publications*

- Nakhutsrishvili, G. & Abdaladze, O. 2018: Botanical and ecological research in the Kazbegi region. – Pp. 2015-2020 in: Antidze, N. (ed.), Museum and cultural heritage. – Tbilisi [in Georgian]0.

**References**

- Nakhutsrishvili, G., Abdaladze O. & Batsatsashvili, K. 2021: Ecological Gradients (West- East) and Vegetation of the Great Caucasus. – *Bocconeia* **29**: 157-168. <https://doi.org/10.7320/Bocc29.157>
- Tephnadze-Hoernchen, N., Kikvidze, Z., Nakhutsrishvili, G. & Abdaladze, O. 2021: Subalpine vegetation along the soil moisture gradient under the climate change conditions: re-visitation approach (the Central Great Caucasus). – *Bocconeia* **29**: 297-310. <https://doi.org/10.7320/Bocc29.297>

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