Benefit sharing by research, education and knowledge transfer – a success story of biodiversity research in southern Ecuador

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1. Introduction

The Andes of Ecuador are one of the „hottest" hotspots of biodiversity worldwide which, however, is severely endangered by the drivers of global change, in particular by deforestation. Since 13 years, an interdisciplinary consortium of Ecuadorian and German researchers is investigating biodiversity, ecosystem functioning and services, environmental and land-use change effects, and the socio-economic conditions in the valley of the Rio San Francisco. This river breaches through the eastern range of the South Ecuadorian Andes between the provincial capitals Loja and Zamora (for further information refer to Beck et al. 2008, Bendix and Beck 2009). The main goal of the above mentioned research unit ("*Biodiversity and Sustainable Management of a Megadiverse Mountain Ecosystem in South Ecuador*", sponsored by the German Research Foundation) is to develop science-directed recommendations for a sustainable land use portfolio of this biodiversity hotspot, a portfolio that at the same time preserves biodiversity, ecosystem processes and services in the natural system, and rehabilitates attenuated biological diversity and lost usability on the deforested mountain slopes, thus striving for a better livelihood of the local people.

With this, the main goal of the German research program is in full agreement with the intentions of the Convention on Biological Diversity (CBD). By articles 7 (Identification and Monitoring of species, functions, and use) and 12 (Research and Training), joint biodiversity research of scientists from abroad and local researchers is encouraged (UN 1993). Article 12 of the CBD (Research and Training) clearly points on the specific needs of developing countries in scientific and technical education of scientific staff at local universities, where special emphasis of Article 15 is on the access to genetic resources of all partners. Modern technologies of inventorying e.g. the molecular "barcoding" or high resolution spectral remote sensing of the vegetation, are brought in and may encourage the host countries to strive for establishment by their own of the required facilities with the assistance of the guest researchers and their funding (Article 16 of the convention). Sharing knowledge, methods and results requires, on the other hand, unhampered access to the matter of research, the so-called "genetic resources" (Article 15 of the CBD). In the scope of an ecosystem study that term is ambiguous, because water and soil samples could contain useful biological material, however, climatological data could hardly be considered as genetic material. Nevertheless, also such data may be shared under the umbrella of the CBD, following a mutual understanding and acknowledgement of a real partnership. This precondition for successful research in developing countries is summarized under the term Access and Benefit Sharing (ABS) of the CBD.

Effective implementation of the intentions of the CBD, however, requires research as a major component of the mission of universities in the cooperating country. To date, the situation of most Latin American universities is not suitable for basic biodiversity research. Some of the

main reasons for the currently poor situation of these universities which particularly holds for the structure of Ecuadorian universities have been identified by Arocenam and Sutz (2001), Thorn and Soo (2006), University of Cuenca (2006) and Romero (2009) as follows:

- The most universities in Latin America are predominantly teaching universities and not furnished for academic research. Thus, they do not produce (enough PhDs) for tertiary institutions including university staff development.
- Only a low proportion of professors hold a PhD degree which implies mostly undergraduate courses. This academic structure implies that the universities do not produce a sufficient number of highly ranked scientific papers thus compromising their international visibility and competitiveness.
- Even at the few research universities with an appreciable sector for research, new basic knowledge can be rarely generated, partly due to lacking access to cutting-edge research technologies and insufficient infrastructure.
- A brain drain mainly to the US or Europe (but also to the national industry) discourages aspiring young researchers from staying with their local university which is due to a lack of perspectives (permanent position, adequate payment, possibility to gain higher degrees etc.).

Beyond the pure research issues, CBD underlines in article 13 (Public Education and Awareness) the importance of the involvement of national societies regarding the conservation and sustainable use of biological diversity. Particularly, exchange of information with the public gained from technical, scientific and socio-economic research, the transfer of knowledge from basic science to application and public environmental education and training shall foster the public awareness and guarantee the embeddedness of basic biodiversity research activities. To advance acceptance by the public, indigenous and traditional knowledge should be considered in the research programs.

2. The approach of RU816

In accordance with the goals of the CBD, the research activities of the German Research Unit (No 816 of the German Research Foundation) are focused on four pillars:

- Conducting and promoting joint multidisciplinary biodiversity research to investigate biodiversity, ecosystem functioning and ecosystem services under environmental change in the hot spot area of the south-eastern Ecuadorian Andes,
- Supporting academic education, academic staff development and the establishment of relevant research technologies at the Ecuadorian partner universities regarding all interdisciplinary issues of biodiversity research,
- Developing science-directed recommendations for a sustainable management of the extraordinary biodiversity, including complete protection and conservation by adequate use, and supporting respective administrative structures together with the national authorities and NGOs,
- Facilitating transfer of the compiled knowledge to the public to boost awareness at site for the needs and benefits of biodiversity research to safeguard ecosystem services and human well-being, and in turn, to attain acceptance of the local population.

The operation of the German Research Unit in South Ecuador has become an internationally appreciated success story. This success benefited from a well-developed network of focal actors. At first, researchers from Ecuadorian and German universities, but also from a few other countries (Brazil, Perú, Belgium, U. S.) are collaborating in a multi-disciplinary

research approach. The main cooperation partners of the German research group are the two universities in Loja (the Technical UTPL and the National University UNL), but further co-operations in the country are also well-established (e.g. with the University of Azuay in Cuenca, the Pontífica Catholic University of Quito PUCE, the Ecuadorian Weather Service INAMHI). The scientific advisory board of the research unit cooperates with the German (DFG) and Ecuadorian funding agencies (SENACYT, AGECI) to warrant funding for the research programs. Also, the development of the science landscape in southern Ecuador towards a national focal region for biodiversity and biotechnology research and education is discussed between the German-Ecuadorian research consortium of the Research Unit, the funding agencies, the national planning authority SENPLADES and the NGO Nature and Culture International (NCI). Last but not least, the Ministry of Environment (MAE) is supporting the research activities, and, at the same time, benefits from the results with special regard to biodiversity protection and other environmental issues.

2.1 Scientific education and capacity building

Capacity building in Ecuador as one of the major aims of ABS is supported by the research unit in two lines: (i) By including Ecuadorian scientist at all scientific qualification levels in the research program, and (ii) by supporting the autonomous development of scientific staff at the local universities.
In the first line, designing of the research projects of the program is jointly developed by the Ecuadorian and the German principal investigators (PI) while funding of staff (e.g. Ecuadorian and German PhD positions) and instrumentation is mainly provided by the German Research Foundation. Figure 1(a) clearly reveals the very successful capacity building effect reached after 13 years of collaborative research. A reasonable part of the researchers, particularly at the diploma/tesistas and PhD levels are meanwhile Ecuadorian collaborators. It should be stressed that also students from other Latin American countries like Brazil and Peru have been and still are attracted by the research program. The development of the share of the Ecuadorian researchers over 13 years of research (Fig. 1b) reveals that the absolute number but also the academic level of the contributing Ecuadorian scientists has been significantly increased.

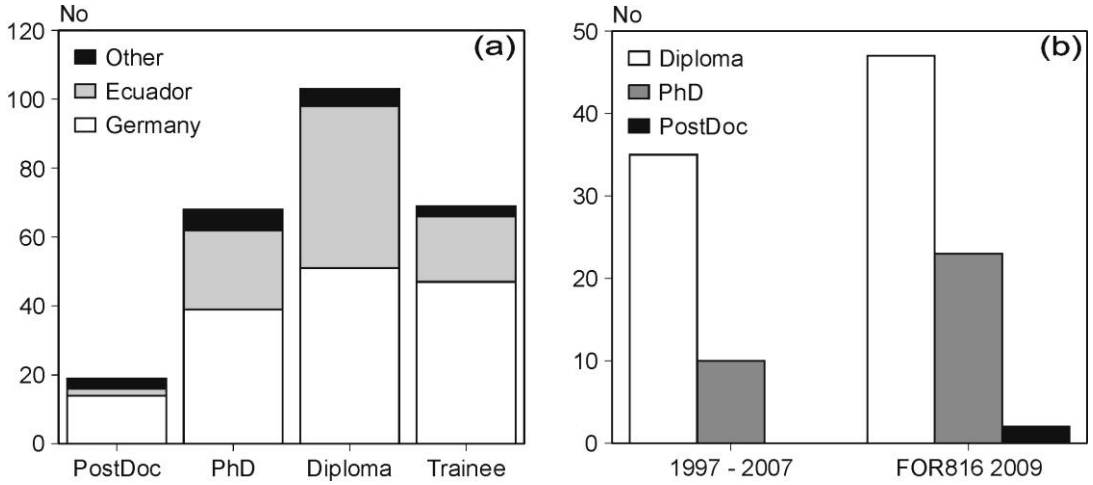

Fig. 1: (a) Researchers at different qualification levels working in the research unit (b) Number of Ecuadorian researchers since the beginning of the research activities in southern Ecuador (Source: RU816 Data Warehouse, December 2009 (www.TropicalMountainForest.org)

This underpins the contribution of the research group to the careers of Ecuadorian scientific staff from PhD students to leader function in university and NGOs. One excellent example is Dr. Juan Pablo Suárez who enrolled at UTPL as a first student for biology. He did his PhD studies in a project (see e.g. Suárez et al. 2006) of a mycorrhiza research group of the university of Tübingen (Germany), but at the same time was instrumental in establishing a Micropropagation and Molecular Biology Lab at his home university. He holds now the position of the Director of Research at UTPL, where he started building up a research group for genetics, acquiring own research funds and establishing collaborations beyond the German research group. A similar career push-up could be achieved with a candidate of the National University UNL. Another successful Ecuadorian PhD student has been appointed Director of an Ecuadorian National Park. Based on three consecutive memoranda of understanding since 1997 particularly emphasizing capacity building, many students at all levels have got training in the scope of the research program (among others, currently 8 PhD students). Activities were not only in fieldwork, but also on technical skills in internships in German universities. One recent achievement is the launch of two Ecuadorian-German research projects which were designed by colleagues of the UNL and submitted to the Ecuadorian funding agency SENACYT.
Altogether, the success in staff promotion has led to a greater international visibility of the research activities of the collaborating Ecuadorian universities (especially UNL and UTPL). This is mainly due to the increase of contributions in international peer-reviewed journals (Fig. 2) where the relative contributions by Ecuadorian scientist as co-authors and first authors have steadily increased over the years.

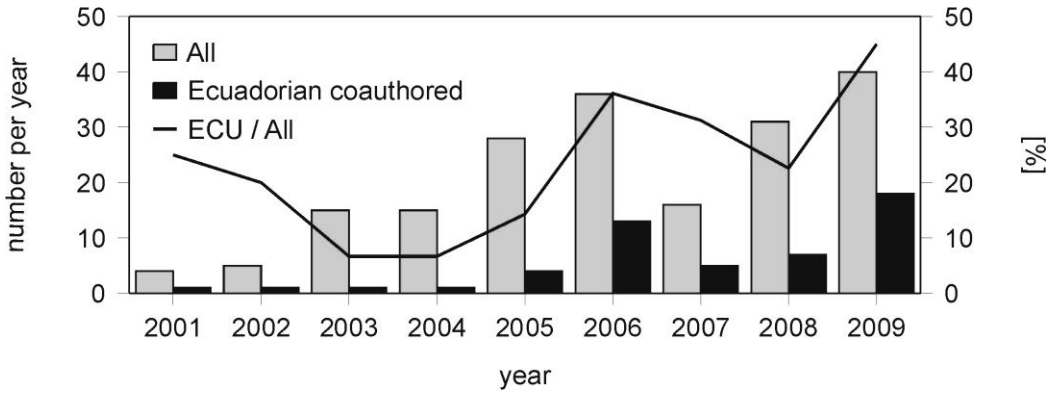

Fig. 2: Articles in international peer-reviewed journals (Source: RU816 Data Warehouse, December 2009)

The second line which promotes autochthonous university staff, as claimed by the World Bank (Thorn and Soo 2006) was started in 2009 with a particular co-operation program between the German Research Foundation (DFG) and South Ecuadorian universities. Here, the project design is prepared by Ecuadorian PIs adapting the objective to the program of the German research group to warrant a synergetic use of available resources. The Ecuadorian PhD students and their living costs are provided by the Ecuadorian side whereas the DFG supports grants for visiting the home institutes of the German co-advising project partners.
In addition to scientific staff promotion, technical staff at the Ecuadorian university is trained by the German scientists to properly operate jointly established research infrastructure (e.g. sophisticated biochemical and genetic laboratory facilities, field instrumentation etc.).

2.2 Shared access to research facilities, technology and information

The importance of the research program for the development of the universities in southern Ecuador is obvious. At the beginning of the research in 1997, UTPL was a pure teaching

university without a biology department. After 13 years of joint research, the situation has dramatically changed. Recently, UTPL has promoted biological research personal and infrastructure as well as teaching staff. Through the collaboration with the German program, laboratories for molecular biology, soil analysis (including the analysis of trace gas fluxes) and geographical information systems have been established and equipped. Improving their facilities in this way, the cooperating Ecuadorian university could increase its international attractiveness far beyond the cooperation with the German research group: UTPL hosts more than 600 visiting professors per year and supports more than 300 research visits of own scientists abroad. Funding of science development from national agencies could be increased to 4 Million US$ in 2009.

At the UNL, the joint research program similarly led to the establishment and extension of important research infrastructure for use by all partners: (i) Improvement of the soil analysis lab, (ii) complementation of the UNL Herbarium "Reinaldo Espinosa" by 3.500 new specimens, (iii) improvement of the equipment of UNL laboratories for dendrochronology and (iv) plant physiology, and (v) a tree nursery which is indispensable for the long-term reforestation experiments of the research group.

Very important for multidisciplinary biodiversity research in a foreign country is the availability and guaranteed unlimited access to a research platform which includes a research station and well managed experimental and monitoring sites. First of all, the research program benefits from the close cooperation with the local foundation NCI which provides the well-equipped research station Estación Científica San Francisco (ECSF). This station offers accommodation and board, provides basic research infrastructure like soil-, water- and IT-labs, runs a herbarium and a lecture hall. Furthermore, many parts of the research area are owned by the foundation, e.g. the protected natural mountain forest of the Reserva Biologíca San Francisco (RBSF). Similarly, wide areas where the natural forest has been converted into pastures or exotic tree plantations are also available for research. The access to research areas of the cooperating universities is also an option.

The research group's gained knowledge on biodiversity and underlying ecosystem processes/services is compiled in a central data warehouse (Nauß et al. 2007) which is open to all contributing scientist and cooperating organizations at different scientific levels. To date, the data warehouse is not only keeping more than 19 Mio stored data, but also offers access to the digital publications which is normally hardly possible at Ecuadorian universities.

2.3 Potentials of a transfer of basic research to application

The overarching objectives of the research program (sustainable, science-directed development) imply that relevant results from basic research should be developed into application to serve the local society with regard to biodiversity protection, rehabilitation of lost biological diversity, formerly cultivated areas and ecosystem services. Two land use options are intensively investigated. The mountain forest in Ecuador vanishes rapidly by slash-and-burn for the attainment of pasture land. Unfortunately, many of these pastures are soon overgrown by aggressive weeds like bracken fern, becoming abandoned after only a few years of use which increases the pressure on the remaining extremely biodiverse mountain forest (refer to Hartig and Beck 2003). To safeguard usability of the pastures and thus the livelihood of the local farmers, sustainable pasture management strategies are under experimental investigation. Even active pastures are poor in biological diversity (e.g. Nöske et al. 2008) as compared to the natural forest, and with the loss of biodiversity, ecosystem services are degraded, too (e.g. climate regulation function; Fries et al. 2009). One intensively studied landuse option is reforestation with native tree species. This is expected to yield a close-to natural mountain forest (Weber et al. 2008), rehabilitating biodiversity and ecosystem services and, at the same time improving the revenue for the land owners (Knoke et al. 2009).

To that end the research program investigates also the potential of indigenous forms of land use for an involvement in a sustainable land use portfolio (Pohle and Gerique 2008).
The German Research Foundation is currently discussing a new funding instrument ("Transfer Project") which shall promote the development of knowledge from basic research into application. In many cases this means research into scale-up. The idea is to co-finance such transfer projects, i.e. that also the Ecuadorian partner would contribute part of the financial or material resources which are necessary for that kind of research.
In that respect, the foundation NCI plays a focal role as mediator between the Ecuadorian-German research consortium, the national and local administration and the public. Several applied programs are conducted by NCI where information from the research program is used: (i) Supporting local communities in sustainable land use management, (ii) creating a regional system of conservation, (iii) organizing a regional public water fund (FORAGUA), (iv) improving watershed management and promoting hydro-power, and (v) advancing environmental education. One milestone of successful cooperation was the approval of the UNESCO Biosphere Reserve Podocarpus - El Condor in 2007. The results of the research program were the scientific basis for the preparation of the proposal and the research unit acts as a long-term model project for biodiversity protection and sustainable development for the implementation of the biosphere reserve.

2.4 *Public education and awareness*

The results of the research program are mostly published in English in scientific journals or books, which makes their appreciation by the local people difficult. Thus, it is absolutely necessary to translate the results into layman's language in order to rise awareness and foster the feeling of responsibility of the public for biodiversity and related ecosystem services. In addition environmental information on a more popular scientific level is necessary for stakeholders and interested people. Such activities are regularly organized jointly. One example is the publication of a booklet by NCI and the research program (Kiss and Bräuning 2008) summarizing and "translating" the scientific results into Spanish language for a wider readership. Additionally, annual symposia with keynote talks in Spanish and monthly research meetings, both open to the public, were and are still organized in Loja. The lecture hall building of the research station is used to conduct classes and field courses for pupils on biodiversity and the environment, but also specific courses for the local administration.

3. DFG and the ABS process

As the previous sections show, the research program successfully addresses all claims of the CBD. That is also a precondition to apply for funds related to biodiversity research at the German Research Foundation (DFG 2008). Since 2008, DFG has "Guidelines for funding Proposals Concerning Research Projects within the Scope of the CBD" to fulfill CBD-principles and also to ensure that DFG-funded projects will be conducted in accordance with the CBD-principles. They are part of the approval of an applicant's grant by the DFG, and they are also referred to in the general information for draft grants proposals. It is fair to say, that DFG CBD-Guidelines have two kinds of effects. At the beginning when the researcher is drafting the application for a grant, the guidelines assist him or her in preparing the proposal in compliance with the CBD-principles. Secondly, if the researcher accepts a grant from the DFG, he/she also accepts the regulations of the guidelines.
To keep step with the advance of the CBD-ABS process, DFG has made various efforts over the years: (1) It has established an ABS working group which observes ABS activities at an international level; (2) It employs an ABS program officer; (3) It participates in the Conference of the Parties to the CBD, in ABS working group meetings, it co-hosts workshops

and co-organizes side-events in the scope of workshops and conferences; (4) It has developed a network to improve the information level and awareness of researchers for CBD-issues, especially of ABS measures.

Ecuador is part of the Andean Community (CAN). In 1996, CAN countries (Venezuela, Colombia, Ecuador, Peru, Bolivia) have signed the Andean ABS Decision 391 (http://www.cbd.int/abs/measures/group.shtml?code=am-and), but to date, only Bolivia and Peru brought the regulations into effect. In Ecuador, the granting of a research permission is an administrative decision of the environmental authorities.

The German research group regularly applies for research permission at the Ministry of Environment and fulfils all underlying laws and regulations. One additional benefit besides of the issues mentioned in the previous sections is the contribution of the research program to the national specimen repositories which, at the same time, is a precondition for getting the research permission.

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Appendix: Biographies

Erwin Beck, 02 Nov 1937, was promoted Dr. rer. nat. (1963) in Plant Systematics (with H. Merxmueller) at the University of Munich. After 5 years as Postgraduate Assistant at the Technical University of Munich, he was promoted lecturer for "Botany". In 1970 he was appointed "Associate Professor" at the Botanical Institute of the University of Munich. From 1975 to 2006 he was Full Prof. and Head of the Department of Plant Physiology at the University of Bayreuth. Since 2007 he is Prof. emeritus at the same university. His scientific interests are plant (eco)physiology and molecular biology, plant hormone physiology, biodiversity research, vegetation ecology and ecosystem theory. Since 1979 he is running research projects in the tropics. Until 2007 he was Speaker of the German Research Unit in Ecuador. He served the Academic as Dean of the Faculty, Vice-president of the University, and External Examiner of the University of Nairobi (Kenya) and of Addis Ababa University (Ethiopia). He was elected President of the German Biologists Association, President of the German Botanical Society, President of the German National Committee of the IUBS, Treasurer of the IUBS, and Chairman of the Senate Commission for Biodiversity Research of the German Research Foundation. He served in several evaluation panels, e.g. of the Alexander Humboldt Foundation and was and still is a member of the Editorial Boards of scientific journals. His honours are: Order of Merit of the German Federal Republic, Profesor Honoraria of the Universidad Técnica Particular de Loja (Ecuador), Dr. rer. nat. h.c. from the Technical University of Kaiserslautern (Germany).Contact: erwin.beck@uni-bayreuth.de

Jörg Bendix is professor for Geoecology (with focus on Climatology, Remote Sensing and Evironmental Modeling) at the Philipps University of Marburg (Germany). He studied Geography, Soil Science and Agricultural Water Engineering at the Universities of Trier and Bonn (Germany). He holds a PhD in Geography (Climatology and Remote Sensing, University of Bonn) and a postdoctoral qualification in Geography (habilitation). In 1999 he was appointed as professor for Applied Physical Geography at the Ludwig-Maximilians-University Munich and professor for Geoecology at the University of Marburg in 2000. He is currently expert of the Commission for Earth Science Research of the Academy of Science and Literature (Mainz, Germany), member of the DFG review board (Fachkollegium) Geography, the advisory board of the Society for Tropical Ecology (*gtö*), the DFG Senate Commission on biodiversity research, and is speaker of the DFG-funded research unit 816 "Biodiversity and Sustainable Management of a Megadiverse Mountain Ecosystem in South Ecuador" (www.TropicalMountainForest.org). Contact: bendix@staff.uni-marburg.de

Bruno Paladines is graduated in Ecology and Natural Resource Management at the Friendship University in Moscow (Russia). In August 2000 he finished a Master Program in Human Ecology at the Vrije Universiteit Brussel (Belgium), where his first interest was the study of the interactions between rural communities and the surrounding forest in developing countries. At present, he is a member of Nature and Culture International -NCI-, an NGO settled in Loja – Ecuador. For more than 8 years he has been working with rural communities on projects related with natural resource management and conservation. He is responsible for project design and project management within the organization. At the moment, his main professional interests are centred on the construction of integral conservation and development approaches at local and regional level. Contact: bpaladip@natureandculture.org

Luis Miguel Romero is a Biologist, Philosopher and Ph.D. in Medicine (University of Zaragoza, Spain); he is also a missionary and priest of the Catholic Institution "Idente Missionaries". Since 1977 he has been working as a professor and researcher in different universities: University of Zaragoza, Spain, Catholic University of Bolivia, Universidad

Mayor de San Andrés, Bolivia, Catholic University of Chile and Universidad Técnica Particular de Loja, Ecuador, occupying different administrative positions. He has been a keynote speaker in many conferences and has publications in Biology, Philosophy of Science, Pedagogy, Ethics, Theology, Distance Education and University Management. He has been recently the Rector of the Universidad Técnica Particular de Loja, Ecuador, President of the Inter American Organization for Higher Education, and President of the Latin American Institute for Quality Assurance in Distance Higher Education (CALED); and a member of the board of several organization of higher education in Latin America. Contact: lmromero@utpl.edu.ec

Mónica Ribadeneira Sarmiento is an Ecuadorian environmental lawyer, is a Bachelor of Political and Social Sciences and holds two Masters degrees, one in Environmental Law and other in Management and Administration of Natural Protected Areas, NPA. She has undertaken studies in Economic Law, Intellectual Property Rights, Human Rights and Biodiversity Management. She has studied in Ecuador, Spain, Sweden and Germany. For about 15 years, she has been focussing on CBD issues, mainly access to genetic resources and benefit-sharing ABS. She is an author and co-author of publications and posters on management of NPA and on monitoring legal compliance, including an explanatory guide on the Andean Decision 391, and has written articles about misappropriation cases as well marine genetic resources. Also, she is a designer and an author of on-line courses on ABS. During the past years, she has worked for the Ministry of the Environment, some national NGOs and international development agencies like Inter American Development Bank, USAID, KfW, GTZ, CISP, CARE International, IULA, UNICEF and UNDP, in Ecuador, as well AIDA in USA and VDI in Germany. She is now employed at the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) in Bonn as a Programme Officer for CBD and ABS. Contact: Monica.Ribadeneirasarmiento@dfg.de

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