Obituary and Tribute

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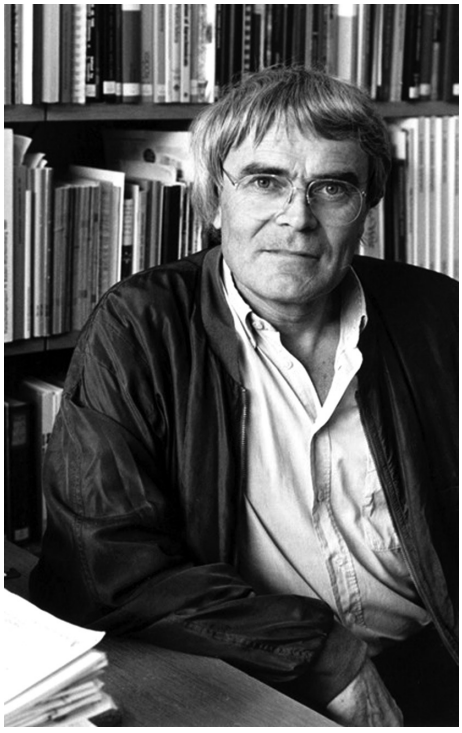
Peter Heinrich Böger, 1935–2015

DOI 10.1515/znc-2016-0120

Abstract: On October 22, 2015, Professor Peter Heinrich Böger, an excellent and internationally highly regarded plant scientist, died in Constance, Germany, at the age of 80 years. He was a broadly oriented researcher of photosynthetic processes, with emphasis on the mode of action of herbicides in chloroplasts and on the biodiversity of nitrogen-fixing cyanobacteria. He was a very active, much committed person, who advanced not only plant science research, but also scientific communication, international cooperation and the promotion of young scientists. His scientific career, his manifold activities as editor and board member, and his merits and honors are described in this tribute.

Keywords: biosynthesis of carotenoids; ecology of cyanobacteria; ferredoxins of algae; mode of action of herbicides; nitrogenase; phytoene desaturase.



Peter Böger in his office at the University of Constance. (Source: Universität Konstanz).

1 Life and career

Peter Böger was born on March 23, 1935, in Bremerhaven, Germany, where he visited the local schools and qualified for admission to university (Abitur). He studied biology and chemistry at the Universities of Munich and Göttingen. In 1963, he received his doctorate under the guidance of Prof. André Pirson at the University of Göttingen with a thesis on the structure-proteid of chloroplasts from unicellular green algae and its relations to chlorophyll (*Das Strukturproteid aus Chloroplasten einzelliger Grünalgen und seine Beziehung zum Chlorophyll*), staying with this group for another year as research assistant.

From 1964 to 1967, he was a post-doctoral fellow at the Charles Kettering Research Laboratory in Yellow Springs, OH, USA, with Prof. Antony San Pietro, known for the detection of photosynthetic NADP reduction. There he worked on photosynthetic electron transport processes including photophosphorylation, i.e. the light-induced ATP formation. After his return to Germany, he first worked as research associate with Prof. Wilhelm Menke in Cologne and in 1970 moved to Prof. Achim Trebst's group at the Ruhr University Bochum, where he received his habilitation (promotion to Privatdozent) in 1970 with a work on *Algenferredoxine*, i.e. the ferredoxins of algae. In 1972, Peter Böger was appointed full professor at the University of Constance on the newly created chair of physiology and biochemistry of plants, which he conceived, organized and successfully headed until he retired and became professor emeritus in 2003. At this reform university founded in 1966, he was substantially involved in the establishment of the Faculty of Biology, where he served as highly esteemed dean from 1981 to 1983. In addition, Peter Böger was also a much valued

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and meritorious coordinator of two particular collaborative research programs (*Sonderforschungsbereiche*) of the German Research Council (Deutsche Forschungsgemeinschaft, DFG) on the limnology of algae in the Lake of Constance. He actively participated in scientific and editorial work for a long time after his retirement.

2 Research topics

As a scientist, Peter Böger had a general interest in the metabolism of plants, algae and cyanobacteria, which he and his students investigated in various biochemical and physiological details. His early research was dedicated to the elucidation of photosynthetic electron processes with emphasis on the redox proteins involved. In this context, he not only worked with higher plants, but often used algae as simpler model systems and already here applied inhibitors of the photosynthetic electron transport as valuable tools. Later, at the University of Constance, he broadened his scientific research, according to his own statement, to the following four main topics:

1. Photosynthetic electron transport, isolation and biochemistry of electron carriers. In this context, he detected that in algae, the carrier plastocyanin can functionally be replaced by a special c-type cytochrome.
2. Characterization of particular strains of nitrogen-fixing cyanobacteria isolated from Lake Constance. Studies on the enzyme nitrogenase and the conditions of N_2 fixation, as well as molecular genetic studies on the population dynamics and taxonomy of unicellular cyanobacteria. This research basically dealt with the ecology and diversity of cyanobacteria with regard to the activities of the enzymes nitrogenase and hydrogenase.
3. Genetic engineering of the carotenoid biosynthesis pathway in algae and higher plants as well as an investigation of the light-induced carotenoid biosynthesis in the fungus *Neurospora*.
4. Mode of action of herbicides in plants, search for target enzymes of herbicides and new agro-chemicals, especially inhibitors of phytoene desaturase, an early enzyme of carotenoid biosynthesis; in addition, elucidation of the mode of action of 'bleaching herbicides' such as inhibitors of protoporphyrinogen oxidase, and of chloroacetamides, which block the formation and chain elongation of long-chain fatty acids. The latter are required for the stabilization of the plant cell membrane; otherwise, plant cells become leaky and die.

3 Publications

Together with his dedicated team, Peter Böger published more than 300 original papers and scientific reviews in internationally renowned journals. A small selection of his papers from different years is given in the References. Moreover, he edited three books on the mode of action of herbicides in plants, two of these with his Japanese colleague Ko Wakabayashi, and all became well-cited reference books.

1. *Peroxidizing Herbicides*, Springer: Berlin - Heidelberg, 1999 (Peter Böger, Ko Wakabayashi, Editors) (ISBN 3-540-64550).
2. *Herbicide Classes in Development*: Mode of Action, Targets, Genetic Engineering, Chemistry. Springer: Berlin – Heidelberg, 2002 and 2011 (Peter Böger, Ko Wakabayashi, Kenji Hirai, Editors) (ISBN 978-3-642-59416-8).
3. *Target Assays for Modern Herbicides and Related Phytotoxic Compounds*, Lewis Publishers, Boca Raton, FL, USA, 1992 (Peter Böger and Gerhard Sandmann, Editors). (ISBN 0-87371-539-X).

4 Peter Böger as reviewer, secretary-general, chairman, organizer, and editor

4.1 Reviewer

Peter Böger served as well-respected reviewer for eco-physiological and eco-toxicological topics in various commissions of the German Federal Ministry of Research and Technology (BMFT), the German Research Council (DFG) and the European Union (EU). In 1985, when the state of Baden-Württemberg established a research promotion program and a center of forest decline research in Karlsruhe, Peter Böger was the principal reviewer and member of the grant decision committee for more than 8 years.

4.2 European engagement, Secretary-General of FESPP

During his research stay in the USA, Peter Böger much valued the annual meetings of the American Society of Plant Physiology, ASPP, where he participated in scientific exchange and discussions on open scientific questions, which are so essential for scientific progress. It was clear to him as well as to many other young German and European post-doctoral plant scientists in the USA that there was a need in Europe for a similar, large forum of plant

physiologists for presenting and discussing their research results. Thus, in the 1970s, Peter Böger, together with many other German and European colleagues, was a strong promoter of the founding of a *Federation of European Societies of Plant Physiology*, FESPP, which was finally established in 1978 and initially comprised primarily the Western European societies, yet in 1988 the respective societies from all Eastern European countries joined as well. From 1978 to 1984, Peter Böger served as Chairman of the Advanced Courses Committee of the Federation and from 1984 to 1988 as Secretary-General of FESPP. Figure 1 shows him as Secretary-General at the 5th FESPP Congress in Hamburg.

Figure 1: FESPP Executive Council with Secretary-General Peter Böger (center), Treasurer Cornelis (Cees) Karssen (left) and FESPP-President Hartmut Lichtenthaler (right) at the opening session of the 5th FESPP Congress 1986 in Hamburg. (Source: H. Lichtenthaler).

4.3 Chairman of the "Working-Group (Arbeitskreis) Phytopharmacology"

In 1981, Peter Böger was a founding member of the Working-Group Phytopharmacology of the German Phytomedical Society, which annually investigated and discussed the mode of action, metabolism, application and breakdown of herbicides, fungicides and other agrochemicals (keyword: 'chemical plant protection'). This circle consisted of plant scientists from several German universities, colleagues from industry and various colleagues from federal and state authorities responsible for the admission of new herbicides. After the early death of the first chairman Franz Müller, Hohenheim, in 1991, Peter Böger took over the chair of this study-group and headed it until 2002, successfully organizing workshops in which new research results were presented and open scientific questions and problems in the applications of agrochemicals were discussed. A photograph (Figure 2) shows him in a phytopharmacology meeting in 1992 at Karlsruhe. In this context, one should also mention the herbicide workshops held between 1980 and 1995 at the Agricultural Research Station of the chemical company BASF at Limburgerhof, Germany, which dealt with the mode of action of new chemical agents, potential new herbicides and fungicides, as well as the search of their possible targets. Together with three groups from other German universities, including my own research group, Peter Böger and some of his PhD students involved in this research were regular participants in these workshops.

Figure 2: Participants of the 12th Phytopharmacology Workshop of the German Phytomedical Society at the University of Karlsruhe in 1992. First row from left: Michel Couderchet (Reims), Gerhard Sandmann (Frankfurt), Peter Böger (Konstanz), Hartmut Lichtenthaler (Karlsruhe), and Klaus Pfister (Basel). (Source: G. Sandmann).

4.4 Participant of the International Herbicide Workshops

Peter Böger, like me, was a regular participant in the international workshops "Herbicides Active in the Chloroplast", which were coordinated by Prof. Achim Trebst, Bochum. These discussion-meetings on the newest findings on the mode of action of new herbicides and inhibitors active in the chloroplasts took place between 1977 and 1992, usually shortly before or after the International Congresses of Photosynthesis. These were held in a different country every 3 years since 1968, and in 1992, the congress took place in Japan. Participants were mostly university groups from the United States, Germany, England, Switzerland, France and Japan, together with their colleagues of the chemical industries of these countries. One of these international workshops "Herbicides Active in the Chloroplast" was held in Monheim, Germany in 1989, and the proceedings were published in Zeitschrift für Naturforschung C, with Peter Böger as editor [1]. A photograph from this meeting is shown in Figure 3.

Figure 3: Peter Böger (left) with Gerhard Sandmann (center), Frankfurt, and Joseph (Jossi) Hirschberg (right), Jerusalem, at the international conference "Herbicides active in the chloroplast" held 1989 at the Bayer CropScience Center in Monheim, Germany. (Source: J. Hirschberg).

4.5 Participant of the Photosynthesis Workshops in South-West Germany, 1980–2004

The regular photosynthesis workshops were 1- or 2-day meetings for graduate and PhD students of research groups with common interests in photosynthesis, originally from four and later from seven universities in South-West Germany. These meetings were initiated in 1980 by Hartmut Lichtenthaler (Karlsruhe) together with Peter Böger (Constance), Manfred Kluge (Darmstadt) and Aloysius Wild (Mainz). Later, research groups from other universities joined: in 1984, that of Heinrich Fock (Kaiserslautern); 1994, Wolfgang Haehnel (Freiburg); and 1999, Jürgen Feierabend (Frankfurt). These workshops were a forum created primarily for graduate students and young coworkers for the presentation and discussion of their first scientific results. In fact, these workshops served to promote and support the new generation of scientific academics. From 1980 to 2004, 21 photosynthesis workshops were held, and in 1982, 1988, 1994 and 2001, they took place in Constance and were successfully organized by Peter Böger (see [2]).

4.6 Coordinator of two Collaborative Research Centers of the German Research Council, DFG

For about 8 years, Peter Böger was the much appreciated coordinator of the two limnological collaborative research centers (Sonderforschungsbereiche) of the German Research Council DFG, which were initiated together with other colleagues from the University of Constance. Peter Böger's research group contributed essentially to these research endeavors (see section 4.2).

4.7 Participant of the Wallenfels Roundtable Discussions 1984–2003

Between 1984 and 2003, Peter Böger participated in 18 of the 20 photosynthesis roundtable discussions which were organized in Wallenfels, Germany, by Erwin Beck, University of Bayreuth. Initially, Peter Böger presented his newest findings himself, but later passed on this task to one of his young coworkers. During these meetings, Peter Böger proved to be an excellent discussion partner who knew to ask critical and topical questions of general interest.

5 Peter Böger's activities in Japan

Between 1980 and 2000, Peter was (*nota bene* mostly in the academic vacations between semesters) guest professor at the Agricultural Faculty of the Tamagawa University in Tokyo, Japan. There he closely cooperated with Prof. Ko Wakabayashi on the mode of action of herbicides,

Figure 4: Peter Böger at Tamagawa University in Tokyo in 1997 during the meeting of the Japanese Pesticide Society, having just received the Research Award of the Society. (Source: Christa Böger).

Figure 5: Peter Böger (center) with colleagues Hartmut Lichtenthaler (left) and Zdenek Sestàk, Editor-in-Chief of Photosynthetica (right), on the symposium "Photosynthesis and stress" in České Budějovice, Czech Republic, in 1991. (Source: Christa Böger).

e.g. inhibitors of protoporphyrinogen oxidase and phytoene desaturase. Moreover, from 1980 to 2006, he was a member of the Pesticide Science Society of Japan (PSSJ). In 1997, he received the PSSJ Research Award for his basic and valuable research on the 'biochemical mode of action of herbicides' (see Figure 4). In addition, he was a member of the Editorial Board of the Japanese Journal of Pesticide Science and an active participant and chairman at the IXth International Congress on Photosynthesis, held in Nagoya, Japan, in 1992.

6 Member of the editorial boards of scientific journals

Peter Böger served on the editorial boards of several journals, such as *Pesticide Biochemistry and Physiology*, USA, from 1984 to 2015, the *Japanese Journal of Pesticide Science* in the 1980s and 1990s, and *Bioscience, Biotechnology and Biochemistry*, Japan. In addition, he was a member of the Advisory Editorial Board of Physiologia Plantarum from 1980 until 1991, and from 1981 until 1993, he was editor for the 'Mini Reviews on Plant Bioenergetics' in this journal, with emphasis on photosynthetic energy metabolism. His mini-reviews were topical and much viewed and valued by the scientific community.

7 Editor-in-Chief of Zeitschrift für Naturforschung C, Biosciences (ZNC)

From 1974 to 1994 Peter Böger was a member of the Advisory Editorial Board of ZNC, and from 1994 to 2011, he was its responsible and meritorious main editor, initially with the title Executive Editor (1994–2002) and thereafter Editor-in-Chief. During this period, he achieved great recognition from the scientific community for his valuable editorial activities and also for encouraging authors to improve their manuscripts by conducting complementary experiments to allow firmer conclusions from their results. One of his ambitious decisions was to open this journal, covering all fields of the biosciences, for contributions of authors from countries with a less developed scientific infrastructure [3]. In addition, he encouraged other colleagues to become guest editors for selected papers presented at special symposia. In this context, one should mention the special issue of 1999 with Gabor Horváth and Zoltán Szigeti as guest editors, which contained the major contributions of the International Workshop 'Stress Synergisms in Plants' held at Tata, Hungary, in 1998 [4]. Peter Böger demonstrated his particular interest in more general photosynthetic topics such as 'photosynthesis and stress', by his active participation in a stress symposium held in Budweis, Czech Republic, in 1991 (see Figure 5). After his retirement in 2003, he continued to work as Editor-in-Chief

of ZNC, until his declining health forced him to hand this task over to others in 2011.

8 Honors

For his scientific achievements, Peter Böger received the following scientific honors: In 1990, the Foundation for Environment and Habitation in Baden-Württemberg bestowed upon him, together with two colleagues of the University of Constance, a prize for outstanding research in environmental sciences. In 1994, he was distinguished as honorary member of the Weed Science Society of America, WSSA. In 1997, he received the Research Award of the Pesticide Science Society of Japan, and in 2000, during the FESPP Congress in Budapest, he was appointed Honorary Member of the Hungarian Society of Plant Physiology. A photograph shows him on this event together with other colleagues (Figure 6).

9 Final remarks

As an engaged and dedicated scientist, an academic teacher, a lecturer and reviewer, as Editor-in-Chief and Secretary-General of the FESPP, as well as chairman and spokesman of collaborative research groups, Peter Böger acquired great international recognition. At meetings, he was a much appreciated participant, because he gave essential impulses, brought in new arguments and corrected colleagues, young and old, when required, and this he always did in a friendly, gentle, and helpful manner. He was 'a brilliant example of the Pirson School of engaged plant physiologists of Göttingen', as expressed by his colleague Prof. Achim Trebst.

As a human being, as scientist and as academic teacher, Peter Böger excellently managed to seize opportunities and to create lasting achievements. He put great demands on himself and performed valuable pioneering work. He was actively involved in shaping the enormous development and progress of research in the fields of photosynthesis, carotenoid biosynthesis, the mode of action of herbicides, as well as of the physiology, biochemistry and ecology of algae and nitrogen-fixing cyanobacteria. Peter Böger stimulated scientific communication and cooperation through his service on committees as well as executive and editorial boards. Despite his declining health in his last years, he displayed continuing interest in new scientific developments, and during my visits with him in Constance in these years, he enjoyed discussing the significance of the latest research results.

Peter had the fulfilled life of a dedicated scientist who had the great luck and good fortune to find in his wife Christa a very appreciative and sympathetic partner who understood and fully supported his endeavors. Peter is survived by his wife Christa and the family of his son Florian with his grandson Moritz.

Figure 6: Peter Böger (second from right) in 2000 at a meeting of the Hungarian Society of Plant Physiology in Budapest at which the honorary membership of the society was bestowed on him. The others are from the left: Zoltán Szigeti (secretary-general of the society), Reto Strasser, Hartmut Lichtenthaler, Laszlo Erdei (president of the society), Matilde Baron, and Michael C.F. Proctor. (Source: Z. Szigeti).

The international photosynthesis community, his colleagues in the Federation of European Societies of Plant Biology, FESPB, and his close scientific friends in Germany, USA, Hungary, Spain and Japan, mourn for an outstanding personality and highly esteemed friend. It was a great joy and satisfaction for the author of this Tribute to be able to cooperate with Peter Böger and to accompany him as a friend and colleague over more than 40 years.

Acknowledgments: I am very grateful to Christa Böger as a valuable source of facts on Peter's life, to Prof. Gerhard Sandmann, Frankfurt, Peter's coworker and colleague, for information on Peter's scientific research, and to professors Achim Trebst, Bochum, Erwin Beck, Bayreuth, Jossi Hirschberg, Jerusalem, Heinz Rennenberg, Freiburg, Zoltán Szigeti, Budapest, and Koichi Yoneyama, Utsonomiya, Japan, for additional information.

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