



NEW PERSPECTIVES ON THE BIOLOGY OF NECTARIES AND NECTARS

EDITED BY: Clay Carter, Robert W. Thornburg and Massimo Nepi
PUBLISHED IN: Frontiers in Plant Science



frontiers

Frontiers Copyright Statement

© Copyright 2007-2019 Frontiers Media SA. All rights reserved.

All content included on this site, such as text, graphics, logos, button icons, images, video/audio clips, downloads, data compilations and software, is the property of or is licensed to Frontiers Media SA ("Frontiers") or its licensees and/or subcontractors. The copyright in the text of individual articles is the property of their respective authors, subject to a license granted to Frontiers.

The compilation of articles constituting this e-book, wherever published, as well as the compilation of all other content on this site, is the exclusive property of Frontiers. For the conditions for downloading and copying of e-books from Frontiers' website, please see the Terms for Website Use. If purchasing Frontiers e-books from other websites or sources, the conditions of the website concerned apply.

Images and graphics not forming part of user-contributed materials may not be downloaded or copied without permission.

Individual articles may be downloaded and reproduced in accordance with the principles of the CC-BY licence subject to any copyright or other notices. They may not be re-sold as an e-book.

As author or other contributor you grant a CC-BY licence to others to reproduce your articles, including any graphics and third-party materials supplied by you, in accordance with the Conditions for Website Use and subject to any copyright notices which you include in connection with your articles and materials.

All copyright, and all rights therein, are protected by national and international copyright laws.

The above represents a summary only. For the full conditions see the Conditions for Authors and the Conditions for Website Use.

ISSN 1664-8714

ISBN 978-2-88945-996-4

DOI 10.3389/978-2-88945-996-4

About Frontiers

Frontiers is more than just an open-access publisher of scholarly articles: it is a pioneering approach to the world of academia, radically improving the way scholarly research is managed. The grand vision of Frontiers is a world where all people have an equal opportunity to seek, share and generate knowledge. Frontiers provides immediate and permanent online open access to all its publications, but this alone is not enough to realize our grand goals.

Frontiers Journal Series

The Frontiers Journal Series is a multi-tier and interdisciplinary set of open-access, online journals, promising a paradigm shift from the current review, selection and dissemination processes in academic publishing. All Frontiers journals are driven by researchers for researchers; therefore, they constitute a service to the scholarly community. At the same time, the Frontiers Journal Series operates on a revolutionary invention, the tiered publishing system, initially addressing specific communities of scholars, and gradually climbing up to broader public understanding, thus serving the interests of the lay society, too.

Dedication to Quality

Each Frontiers article is a landmark of the highest quality, thanks to genuinely collaborative interactions between authors and review editors, who include some of the world's best academicians. Research must be certified by peers before entering a stream of knowledge that may eventually reach the public - and shape society; therefore, Frontiers only applies the most rigorous and unbiased reviews.

Frontiers revolutionizes research publishing by freely delivering the most outstanding research, evaluated with no bias from both the academic and social point of view. By applying the most advanced information technologies, Frontiers is catapulting scholarly publishing into a new generation.

What are Frontiers Research Topics?

Frontiers Research Topics are very popular trademarks of the Frontiers Journals Series: they are collections of at least ten articles, all centered on a particular subject. With their unique mix of varied contributions from Original Research to Review Articles, Frontiers Research Topics unify the most influential researchers, the latest key findings and historical advances in a hot research area! Find out more on how to host your own Frontiers Research Topic or contribute to one as an author by contacting the Frontiers Editorial Office: researchtopics@frontiersin.org

NEW PERSPECTIVES ON THE BIOLOGY OF NECTARIES AND NECTARS

Topic Editors:

Clay Carter, University of Minnesota, United States

Robert W. Thornburg, Iowa State University, United States

Massimo Nepi, University of Siena, Italy



Image: Massimo Nepi

The number of currently known, described and accepted plant species is ca 374,000, of which approximately 295,00 (79%) are angiosperms. Almost 90% of this huge number of flowering plants is pollinated by animals (mostly insects) via nectar-mediated interactions. Notably, three-fourths of the leading global crop plants produce nectar and are animal pollinated, which is estimated to account for one-third of human food resources. Nectar can also be produced on tissues outside of flowers, by so-called extrafloral nectaries, and commonly mediate interactions with 'body-guard' ants and other pugnacious insects that defend the plant from herbivores. Extrafloral nectar is present in almost 4,000 plant species, a majority of them in the angiosperms. This brief summary on the occurrence of nectar in the plant kingdom is just to highlight that nectar has a fundamental role in two basal functions that allow the maintenance of our ecosystems: sexual plant reproduction and protection of plants from herbivory. Despite playing essential ecological and evolutionary functions, our current knowledge about nectar is largely incomplete;

however, new research directions and perspectives on nectaries and nectars have arisen in recent years.

In the last two decades, there were only a few 'moments' in which nectar was the main character in international meetings or in published books. In 2002, the first (and only) international meeting "Nectar and nectary: from biology to biotechnology" dedicated exclusively to nectar and nectaries was held in Italy (Montalcino, Siena) and in 2003 the proceedings were published in a special volume of *Plant Systematics and Evolution* (238, issue 1-4). In 2007, the book *Nectar and Nectaries* was published (Springer) with most of the contributions provided by authors that attended the meeting in Italy. Another book dedicated to nectar was published in 2015 (*Nectar: Production, Chemical Composition and Benefits to Animals and Plants*, Nova Science Publishers) covering aspects mainly related to nectar chemical composition and plant-pollinator interactions. Similarly, symposia focused on nectar have been organized within the International Botanical Congress in 2011 and 2017.

Considering that the last few years has yielded essential developments in the understanding of nectar biology, we thought now is the moment to further stimulate research on this important topic. This aim has been met through 18 papers published in our Research Topic *New Perspectives on the Biology of Nectaries and Nectars*, with subjects spanning evolution and ecology to nectar chemistry and nectary structure.

Citation: Carter, C., Thornburg, R. W., Nepi, M., eds. (2019). *New Perspectives on the Biology of Nectaries and Nectars*. Lausanne: Frontiers Media.
doi: 10.3389/978-2-88945-996-4

Table of Contents

NECTAR PROTEOMICS AND METABOLOMICS

- 06** *Common Features Between the Proteomes of Floral and Extrafloral Nectar From the Castor Plant (*Ricinus Communis*) and the Proteomes of Exudates From Carnivorous Plants*
Fábio C. S. Nogueira, Andreza R. B. Farias, Fabiano M. Teixeira, Gilberto B. Domont and Francisco A. P. Campos
- 15** *Sex-Dependent Variation of Pumpkin (*Cucurbita maxima* cv. *Big Max*) Nectar and Nectaries as Determined by Proteomics and Metabolomics*
Elizabeth C. Chatt, Patrick von Aderkas, Clay J. Carter, Derek Smith, Monica Elliott and Basil J. Nikolau
- 26** *Characterization of a L-Gulono-1,4-Lactone Oxidase Like Protein in the Floral Nectar of *Mucuna sempervirens*, Fabaceae*
Hong-Xia Zhou, Richard I. Milne, Xue-Long Ma, Yue-Qin Song, Jian-Yu Fang, Hang Sun and Hong-Guang Zha

MECHANISM OF NECTAR PRODUCTION AND NECTARY STRUCTURE

- 36** *Nectar Sugar Modulation and Cell Wall Invertases in the Nectaries of Day- and Night- Flowering *Nicotiana**
Kira Tiedge and Gertrud Lohaus
- 48** *Nectar Analysis Throughout the Genus *Nicotiana* Suggests Conserved Mechanisms of Nectar Production and Biochemical Action*
Fredy A. Silva, Adel Guirgis and Robert Thornburg
- 59** *The Octadecanoid Pathway, but not *COI1*, is Required for Nectar Secretion in *Arabidopsis thaliana**
Anthony J. Schmitt, Rahul Roy, Peter M. Klinkenberg, Mengyuan Jia and Clay J. Carter
- 73** *Nectar-Secreting and Nectarless Epidendrum: Structure of the Inner Floral Spur*
Małgorzata Stpiczyńska, Magdalena Kamińska, Kevin L. Davies and Emerson R. Pansarin
- 94** *Functional Diversity of Nectary Structure and Nectar Composition in the Genus *Fritillaria* (Liliaceae)*
Katarzyna Roguz, Andrzej Bajguz, Agnieszka Gołębiewska, Magdalena Chmur, Laurence Hill, Paweł Kalinowski, Jürg Schönenberger, Małgorzata Stpiczyńska and Marcin Zych

NECTAR AND PLANT-ANIMAL INTERACTIONS

- 115** *Using Nectar-Related Traits to Enhance Crop-Pollinator Interactions*
Jarrad R. Prasifka, Rachel E. Mallinger, Zoe M. Portlas, Brent S. Hulke, Karen K. Fugate, Travis Paradis, Marshall E. Hampton and Clay J. Carter
- 123** *Sweet Scents: Nectar Specialist Yeasts Enhance Nectar Attraction of a Generalist Aphid Parasitoid Without Affecting Survival*
Islam S. Sobhy, Dieter Baets, Tim Goelen, Beatriz Herrera-Malaver, Lien Bosmans, Wim Van den Ende, Kevin J. Verstrepen, Felix Wäckers, Hans Jacquemyn and Bart Lievens

- 136 *Biochemical Traits in the Flower Lifetime of a Mexican Mistletoe Parasitizing Mesquite Biomass***
Elizabeth Quintana-Rodríguez, Alan Gamaliel Ramírez-Rodríguez, Enrique Ramírez-Chávez, Jorge Molina-Torres, Xicotencatl Camacho-Coronel, José Esparza-Claudio, Martin Heil and Domancar Orona-Tamayo
- 149 *Reduced Responsiveness to Volatile Signals Creates a Modular Reward Provisioning in an Obligate Food-for-Protection Mutualism***
Omar F. Hernández-Zepeda, Rosario Razo-Belman and Martin Heil
- 162 *Ant-Pollinator Conflict Results in Pollinator Deterrence but no Nectar Trade-Offs***
Nora Villamil, Karina Boege and Graham N. Stone
- 176 *Crop Domestication Alters Floral Reward Chemistry With Potential Consequences for Pollinator Health***
Paul A. Egan, Lynn S. Adler, Rebecca E. Irwin, Iain W. Farrell, Evan C. Palmer-Young and Philip C. Stevenson
- 190 *Nectar Replaced by Volatile Secretion: A Potential New Role for Nectarless Flowers in a Bee-Pollinated Plant Species***
Elza Guimarães, Priscila Tunes, Luiz D. de Almeida Junior, Luiz C. Di Stasi, Stefan Dötterl and Silvia R. Machado
- 213 *The Evolution of Sexual Fluids in Gymnosperms From Pollination Drops to Nectar***
Patrick von Aderkas, Natalie A. Prior and Stefan A. Little
- 234 *Nectar in Plant–Insect Mutualistic Relationships: From Food Reward to Partner Manipulation***
Massimo Nepi, Donato A. Grasso and Stefano Mancuso

NECTAR AND CLIMATE CHANGE

- 248 *Differential Effects of Climate Warming on the Nectar Secretion of Early- and Late-Flowering Mediterranean Plants***
Krista Takkis, Thomas Tscheulin and Theodora Petanidou