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Introduction

1.1 Philosophy and Aims of this Book

1.1.1 The Large Solanales Families as a Topic

Solanales are from the Mid-Cretaceous (stem node age: 106 my; crown node age: 100 my) (Bremer et al. 2004). Solanaceae and Convolvulaceae are sisters representing the two large families of this order. Their last common ancestor lived about 70 my ago (Durbin et al. 2000). The main objective of the author is to focus on aspects of our extensive knowledge of secondary metabolites in the plant kingdom in order to account for the specific competitiveness and productivity of these two large Solanales families. To this end, it has been necessary to take a bird's-eye view of 200 years of phytochemical research on the Solanales, since first scientific reports with regard to both families were published in the early nineteenth century. Due to an almost complete lack of phytochemical reports (one single exception) on species of the three remaining, very small families of the order (see Chap. 2), they have not been considered.

1.1.2 General Role of the Secondary Metabolism for a Specific Characterization and Classification of Plant Taxa

While traditional systematics generally focused on morphologic-anatomical characters of plants, in some cases chemotaxonomic aspects with regard to low molecular secondary metabolites were also considered. However, plant biochemistry and chemotaxonomy normally played a minor role in classification. In contrast, phylogenetic approaches to plant systematics, based on (macro)molecular cladistic analyses, have received an extraordinary, increasing significance during the past 25 years (e.g., Judd et al. 1999). In the author's opinion, our extensive knowledge of secondary metabolites has not yet been integrated into the **characterization** of plant families, genera, and species to an extent appropriate to its significance. There are enormous numbers of flora from all over the world which document and maintain in

Eckart Eich, *Solanaceae and Convolvulaceae: Secondary Metabolites*

detail the morphologic-anatomical characters of the different taxa as well as their phytogeographic distribution. There are also extensive, daily growing databases available on specific DNA sequences of many plant species or even on their whole genome. These fields of botanical sciences have been used to characterize plants, especially on the species level.

On the other hand, plant biochemistry is still playing a minor role with regard to the specific characterization of plants. The primary metabolism of plants is more or less ubiquitously the same with few exceptions, e.g., C3 vs C4 plants. Therefore, it is of minor if any use for the characterization of the different taxa. The secondary metabolism as far as low-molecular constituents are concerned can add further important information to the characterization of taxa on different levels. Normal flora written for geographically restricted areas only occasionally included some information on secondary metabolites, e.g., "Flore de Madagascar et des Comores, famille 171, Convolvulaceae" on two pages (Deroin 2001). As a rare exception, the comprehensive monograph "Genera Solanacearum" (Hunziker 2001), based traditionally on morphologic/anatomical characters plus detailed information on chromosome numbers, also included aspects of the secondary metabolism – fortunately from the phytochemical point of view. As well as a short initial overview of the phytochemistry of the family, some limited but valuable information predominantly on groups/subgroups of secondary metabolites nested within the corresponding genera sections – exactly documented by references – were given. However, this information is more genus-orientated, i.e., not species-specific.

1.1.3 Bird's-Eye View of Two Centuries of Phytochemical Research on Solanaceae and Convolvulaceae

The author wants to place far greater emphasis on the integration of specific biochemistry into the individual characterization of taxa in the field of the two large Solanales families. In so doing, he is trying to contribute to a more interdisciplinary way of looking at things by combining botanical and chemical sciences. Chemical characters identified in single species in countless chemistry-oriented papers are not really noticed by botanists though they may be of additional value for the characterization of the respective species. It is of little use to note that a species or any other taxon contains, e.g., "alkaloids" or – slightly more specific – "tropane alkaloids". There are tens of thousands of alkaloids and hundreds of tropane alkaloids. The presence or absence of any single alkaloid or any other metabolite is a specific character and may contribute to the characterization of a taxon.

Similar to other characters, e.g., morphological ones, it must be taken into account that there may be qualitative and quantitative differences in any species due to intraspecific, ontogenetic, and morphogenetic variability, respectively.

Furthermore, from the ecological point of view, differentiation is necessary; it is usually not a class/group of metabolites which is associated with a certain activity. In contrast, two structurally closely related compounds may show clearly different effects.

Every single alkaloid as well as any other metabolite is more or less "bioactive" but in individually diverging qualities (effects, mechanisms of action). Its individual potency and its content (high or low accumulation or presence in traces) in the living plant species are of considerable significance. To come back to the example of tropane alkaloids, only a small subgroup of them (3α-tropoyloxytropanes and closely related congeners such as hyoscyamine/atropine) is highly poisonous due to an anticholinergic potency. The vast majority of tropane alkaloids do not possess this property.

Due to their relationship with botany and chemistry, other disciplines, such as pharmacognosy, pharmacology/toxicology, agricultural and food sciences, ecology etc., also play a part in this interdisciplinary approach.

Therefore, the author's objectives are to

- Document the secondary metabolites of the Solanaceae and Convolvulaceae discovered and structurally elucidated in 200 years of phytochemical research as far as low-molecular compounds ("small molecules") are concerned
- Describe the peculiarities of their secondary metabolism as compared to other plants in the plant kingdom, with main focus on angiosperms
- Show common features in secondary metabolism of both families, as well as their chemotaxonomic relationships
- Demonstrate the special qualities of the family Solanaceae vs the family Convolvulaceae, i.e., their differences
- Compare the special qualities on different intrafamilial taxonomic levels (subfamilies, tribes, genera, subgenera, species) of both families, in certain cases also on different intraspecific taxonomic levels (subspecies, sections) of both families
- Consider and integrate the ecological, pharmacological/toxicological, and economic significance of metabolites from both families

1.2 Secondary Metabolism of the Large Solanales Families

1.2.1 Historical Background

The discovery of morphine as the sleep-inducing principle ("principium somniferum") of the opium poppy, *Papaver somniferum* L. (Papaveraceae), by the German apothecary Friedrich Wilhelm Sertürner (1783–1841) in 1805 is of particular significance in the history of organic chemistry. It represented not only the first isolation of a basic plant metabolite, but also at least one of the first isolations of a secondary metabolite in the plant kingdom at all (Sertürner 1805; 1817). It was the initial and stimulating step in the search for further basic constituents. Particularly toxic plants have been screened for such compounds, which were named "alkaloids" (alkali-like) according to the proposal of Meissner (1819). It was therefore natural to look at poisonous species like the solanaceous herbs *Solanum nigrum* (black nightshade), *Nicotiana tabacum* L. (Virginian tobacco), and *Atropa belladonna* L. (deadly nightshade or poison black cherry). Thus, at the

http://www.springer.com/978-3-540-74540-2

Solanaceae and Convolvulaceae: Secondary Metabolites
Biosynthesis, Chemotaxonomy, Biological and Economic Significance (A Handbook)
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2008, XIV, 637 p., Hardcover
ISBN: 978-3-540-74540-2