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Book Review

***Lichen Secondary Metabolites: Bioactive Properties and Pharmaceutical Potential*. Edited by Branislav Ranković.** 2015. Cham, Switzerland: Springer International Publishing. Pp. v + 202, tables, figures (some colour). Page size 235 × 155 mm. ISBN 978-3-319-13373-7 (hardcover), price £126; ISBN 978-3-319-13374-4 (e-book), price £110.50.
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While there has been a succession of treatises compiling the accumulated chemical knowledge of the compounds produced in lichens, from Zopf (1907), through Culberson (1969, 1970) and Culberson *et al.* (1977), to Huneck & Yoshimura (1996), this new book is quite different in that it is the first to focus on what the substances are known to do and what their potential is, rather than their chemical structure and occurrences. Such a title is timely in view of the challenges drug discovery now faces, and the possibilities of genetic engineering that could only have been imagined 10–15 years ago.

The first chapter sets the scene with information on lichen structure, products, and methods of detection, and has a useful tabulation of the applications of some compounds (p. 19), but surprisingly does not place the lichen fungi within the overall fungal phylogeny which would have been helpful for non-lichenologists. That the compounds are products of the fungus alone hardly comes across, nor that they are produced by pathways well known in non-lichenized fungi, including groups with lichenized ancestors such as *Aspergillus* and *Penicillium*, so well known as sources of antibiotics and toxins. As in the case of other fungi, the compounds expressed depend on the growth conditions, so it is hardly surprising that the compounds produced in culture by lichen fungi are not always the same as those that predominate in the thallus in nature. Just what roles the lichen compounds have in the mutualism would also have been of interest to those looking for exploitable products, as these evidently include antibacterial, antifungal, and antifeedant substances. It is remarkable how few mould fungi, for example, are ever encountered on lichens in the field.

Particularly impressive is the second chapter by Stuart D. Crawford on traditional uses of lichens in medicine. At 53 pages, this is twice as long as any other in the book, and is the result of an extraordinarily painstaking literature search. The key feature is a 34 page tabulation (pp. 35–69) with the lichens organized by family and with local as well as scientific names along with the reported activities and literature sources. Species from 52 genera have been used, for example, in treatments for wounds, skin disorders, respiratory and digestive ailments, and further in obstetrics and gynaecology. There is much to fascinate and speculate on here, and this is by far the most comprehensive such compilation ever produced, as far as I am aware. In addition to providing lines for future research, I am sure that recounting some of these ethnolichenological uses will embellish many a field course and lecture. The book is worth buying just for the enjoyment of this scholarly chapter!

The following six chapters each consider a particular kind of application: antimicrobials, anti-oxidant properties, anti-cancer, anti-toxic, anti-genotoxic, and antiviral. About 50% of all lichenized species tested have been found to have some antibiotic properties, something first hinted at in the early tests using crude lichen extracts in the 1940s. The issue is the extent to which the compounds might have adverse effects on humans. Some may have anti-fungal properties, and more information on that aspect would have been useful, as, for example, there is a potential use against wood-rotting basidiomycetes that sadly seems not to be noted here. Lichens are considered a good source of anti-oxidant, but from those I have consumed in China, Japan, and Thailand in teas or food ingredients, it is difficult to imagine them taking off as culinary delights – but then some do have neurotropic (including hallucinogenic) properties when smoked which might have merited more coverage here.

Reports of anti-cancer activities are numerous, and there is an impressive tabulation of these (pp. 131–133), including cases of prostate, ovarian, and colon cancers as well as leukaemias and melanomas. Most of these studies are based on experiments with mice or cell lines, and efficacy in humans has yet to be explored and subjected to rigorous clinical trials. The chapter covering anti-genotoxic effects, focuses on assay methods with a list of species so far tested (pp. 154–155). The penultimate contribution surveys the very limited testing of applications as antiviral compounds.

The final chapter, by Verma and Behera, distils material from the preceding ones, but also mentions applications as analgesics and anti-inflammatory compounds, and further as herbicides and insecticides. They rightly point out that lichens are far behind many other organisms in the extent to which they have featured in bioprospecting programmes, and draw attention to how problems of slow growth rate might be overcome, for example by the use of bioreactors containing composite thalli. The real potential today, however, surely lies in

genomics and the engineering of suites of genes removed from lichen fungi and engineered into rapidly growing filamentous fungi and yeasts. More work has been done in these areas by major pharmaceutical companies than the open scientific literature indicates, but much is regarded as commercially sensitive and so is unavailable to the scientific community at large; that point should perhaps have been stressed. Sadly, a downside to the Convention on Biological Diversity has been a reduction in the bioprospecting activities of the major pharmaceutical companies, which is especially regrettable in view of the need for a new generation of antibiotics. Consequently, I wonder if the therapeutic and commercial potential of lichen products will be properly assessed in the foreseeable future.

Unusually, there is no Preface, no List of Contributors, and, most frustratingly, no Index. There is also unnecessary repetition at the start of several chapters, several explaining what lichens are, their structure and ecology, and some with different estimates of global species numbers. The taxonomy also merited updating throughout, so that the same species was consistently named in all chapters, and unnecessary author citations appear in some but not all. Notwithstanding these points and those made above, the editor has done something not previously attempted on this scale, and is to be congratulated on his foresight in doing that. At last there is a substantial starting point for those wishing to explore the beneficial uses of lichens.

David L. Hawksworth

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