Preface

This new monograph, *Honeybee Nests: Composition, Structure, and Function*, was originally conceived as an extension or revision of an earlier monograph, *Honeybees and Wax: An Experimental Natural History*, published in 1986 by Springer Verlag, Berlin. That monograph was restricted to publications on *Apis mellifera* in the literature up until 1985. However, an extensive search of Google Scholar™ quickly revealed that the number of relevant scholarly references to *Honeybees and Wax* for all species of *Apis* published before 1986 is less than a third of that published since. While *Honeybees and Wax* did, and still does, enjoy fair coverage in contemporary literature, it is beyond doubt very out-of-date. Indeed, the need for a completely new work, and not merely a revision, became apparent when one considers that there has been more than a three-fold increase in the relevant literature.

It is fair to ask 'Is this a new or revised edition?' In the publishing trade it is obvious that there are subjective, qualitative differences between a 'revised edition' and a 'new edition' which hinges on whether the differences constitute something very different, or merely slightly different. In the present case, we can assure the reader that more than 60 % of the text, tables and figures in *Honeybee Nests: Composition, Structure, and Function* represents all new and relevant literature that has appeared in the scientific journals over the past quarter of a century.

We would like to introduce the chapters of this book by reference to the various forms of swarming. Given that there are well over 10,000 publications concerning swarming in honeybees that began to appear in the early eighteenth century, this matter has received intense scrutiny by observations and experiments. However, here we do not attempt a review of this subject, which would require its own volume, but rather restrict comments largely to the circumstances that precede swarming and in terms of 'wax-readiness' once a new nest site has been chosen and the colony has settled there.

The structure of the contents of this new volume is virtually opposite to that of its predecessor. In the 1986 book, the chapters began at the finest level on the nature and production of beeswax, including cytology of the wax gland system, composition and synthesis of beeswax and the energetic considerations that bear on these topics. This section was followed by chapters on the material properties of beeswax and the construction of cells and combs. The final section comprised

large-scale biological factors such as nectar flow, pollen and wax production, the brood nest, the queen and the microenvironment. On the suggestions of several colleagues, in this new work we proceed in precisely the opposite manner, from large and to small. So now it begins with a broad portrait on nesting, which is of fundamental interest to all honeybee biologists, and leaves the physics and chemistry of beeswax and molecular biology of silk to the end, which will have a considerably more finite appeal.

Of particular interest, we have seen, in the last quarter of a century, substantial incursions into the 'old honeybee preserve' of honeybees and wax by major scholarly publications in materials science, structural engineering, molecular biology, polymer chemistry, biomimetics and biomaterials, chemical chromatography, thermal chemistry, food chemistry, applied physics, mathematics, computer modelling and even archaeology. On the purely biological and apicultural side of the coin, there have many major areas of growth in nestmate recognition, social biology, toxicology, pheromones, biomechanics, biochemistry, endocrinology, behavioural ecology, olfactory physiology, evolutionary genetics and chemical ecology to cite a few.

Over the past 25 years studies have been conducted on wax synthesis and secretion in honeybees to identify specific cellular sites for the origin of hydrocarbons and fatty acids within the wax gland complex, and to establish the necessary ultrastructural correlates of this activity and of their transport. These include age-related changes in the composition of hydrocarbons and fatty acids in the epidermal cells, adipocytes and oenocytes. Similarly, with ever-more sophisticated instrumentation, there have been considerable refinements in the wax chemistry and characteristics of different honeybee species and races, their chemometric classification and analyses of the weighted frequency distributions in their carbon chain length variations. There have been major gains in our understanding of the material properties of beeswaxes, their tensile properties, crystal texture and crystallites and wax proteins. We know that honeybee silk is a ά-helical protein, how it behaves at different temperatures, the effects of solvents on silk, its relative crystallinity and molecular dynamics as well as the genetic basis of the honeybee ά-helical fibroin. Chemical differences between scale and comb wax have been determined and how these change in the conversion of newly secreted wax scales into comb.

Of perhaps equal importance is the previously catalogued literature on the Asian species of honeybees which has remained virtually unknown, otherwise untouched and never synthesised. It is apparent from a recent bibliography (Hepburn and Hepburn 2011) that, of some 4,000-odd publications on the Asian species of honeybees, there are several hundred publications dealing with the waxes and silk of these species. All of this hitherto unutilized material has now been analysed and incorporated, where appropriate, in this new text. It should be noted that references to Asian honeybees were sought from the Zoological Record (1864–2003), Apicultural Abstracts (1950–2004) and from Google Scholar™ (2005–2009). However, 95 % of this literature is post-WWII and much of it is now

available through Google Scholar™. Of interest here is a smallish group of papers on the analytical chemistry and physical constants of beeswax, nest site selection and beekeeping trade in beeswax.

The precursor of the present text, *Honeybees and Wax: An Experimental Natural History*, has not been entirely abandoned. Most of the chronological–historical chapters and paragraphs have been greatly edited, compressed, amended and retained. One will still find 'old references' (in fact very, very old) in this new book, which usually means references which only few computer-literate biologists can readily find or even bother to try. Nonetheless, one still encounters comments/queries from journals' referees and even editors as to why such an *old* reference has been cited. The answer here is very basic: we believe in the tradition of 'primacy of discovery'. This tradition has been falling by the wayside and there are particularly egregious examples of ignorance, or worse, incestuous self-aggrandisement in not citing the discoveries of those who came before us.

As an example, Jan Dzierżoń, who discovered parthenogenesis in honeybees and published his observations in 1845, is rarely cited, as a perusal of the literature on parthenogenesis in honeybees over the past 20 years readily confirm. A historical exception is that of François Huber (1814) whose treatise *Nouvelles Observations sur les Abeilles* remains a remarkably modern work. Similarly, the works of Dönhoff and Schirach remain primary source papers. By the same token, a list of Nobel laureates shows individual awards in physics, chemistry and physiology from 1901 until the end of WWII. Only then do we see 'multiple independent, discovery' awards to scientists who made discoveries working independently of each other, which in contemporary science, has become the norm (Merton 1973). The history of discoveries in apicultural science is yet to reach the 'multiple, independent discovery' phase. So we invoke the title of the famous 1897 painting of Paul Gaugin: *D'où Venons Nous/Que Sommes Nous/Où Allons Nous*, questions that are just as fundamental to human existence as to the course of science.

Another difference between the old *Honeybees and Wax* and the present volume is that the current text chapters include references and thus stand alone as journal review papers. This is to accommodate the distribution of electronic copies of individual chapters by the publisher. Readers of the complete text will note that several figures are used in more than one chapter. This occasional duplication arises because such figures are used in different arguments in each particular case.

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