



Beyond *Genera Palmarum*: progress and prospects in palm systematics

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The systematic biology of the palm family (Arecaceae) is probably better known than that of any other tropical plant family of comparable size. As a result, the palms are now regarded as a model group for tropical rain forest research. Ten years ago, the first phylogenetic classification of palms was established as a foundation for the second edition of the palm systematic synthesis, *Genera Palmarum* (GP2), which was published in 2008. Here, we review progress in palm systematics since GP2, summarizing the latest developments in an updated palm classification and schematic phylogenetic tree. To date, the palms comprise 181 genera and c. 2600 species. In just 8 years, six new genera and 200 new species have been described, whereas eight genera have been sunk into synonymy. This reflects the highly dynamic nature of systematic discovery of palms at both forest and phylogenetic frontiers. Palm phylogenetics is a vibrant field, with new trees being generated and utilized in increasingly innovative and ambitious ways. Existing understanding of relationships among the five subfamilies has been confirmed and deep nodes in the subfamilies are crystallizing, especially in subfamilies Arecoidae and Coryphoideae. We conclude that palm systematic knowledge is far from complete and that tools, such as GP2, only stimulate further scientific research and discovery. Despite recent advances, however, many aspects of the palm Tree of Life still remain scarcely known. The vast datasets that the phylogenomic revolution is now bringing to bear on palms promise to elucidate many of these unknowns. The ultimate goal, a species-level phylogenetic tree for palms, is now coming within reach. © 2016 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2016, **182**, 207–233

ADDITIONAL KEYWORDS: Arecaceae – biodiversity – classification – next-generation sequencing – Palmae – phylogenetics – phylogenomics – plant taxonomy – rainforest.

INTRODUCTION

Systematics advances in increments, with each step intended as a successive approximation towards the optimal solution. Palms (Arecaceae) are no exception to this trend. Such has been the success of the palm systematic endeavour that few, if any, tropical plant families of comparable size rival palms in terms of fundamental systematic resources (Govaerts & Dransfield, 2005; Dransfield *et al.*, 2008b; Baker *et al.*, 2009; Baker & Couvreur, 2013a; Govaerts *et al.*, 2015). As a result, palms are now widely regarded as a model group for tropical plant research (Eiserhardt *et al.*, 2011b; Couvreur & Baker, 2013). How have palms, which are notoriously difficult to study, become so well known? Put simply, over decades and centuries, palms have attracted specialists who are drawn to their economic importance (Balick

& Beck, 1990), their keystone role in ecosystems (Eiserhardt *et al.*, 2011b; ter Steege *et al.*, 2013) or perhaps merely to their charisma and the scientific challenge that they present. The work of generations of such palm specialists has laid the foundations of palm biology today.

A BRIEF HISTORY OF *GENERA PALMARUM*

Following the remarkable contributions of 19th and early 20th century innovators, such as Martius, Griffith, Blume, J. D. Hooker, Beccari and Burret (summarized in Dransfield *et al.*, 2008b), the modern palm systematic era dawned with the work of Harold E. Moore Jr. (1917–1980). From his base in the L. H. Bailey Hortorium at Cornell University, Moore became the leading light in palm research from the 1950s to the 1970s. An avid fieldworker, he explored for palms across the globe, studying all but 12 of the

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Prospects In Systematics

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Prospects In Systematics:

Biological Systematics Alessandro Minelli, 2012-12-06 To some potential readers of this book the description of Biological Systematics as an art may seem outdated and frankly wrong For most people art is subjective and unconstrained by universal laws While one picture play or poem may be internally consistent comparison between different art products is meaningless except by way of the individual artists On the other hand modern Biological Systematics particularly phenetics and cladistics is offered as objective and ultimately governed by universal laws This implies that classifications of different groups of organisms being the products of systematics should be comparable irrespective of authorship Throughout this book Minelli justifies his title by developing the theme that biological classifications are in fact very unequal in their expressions of the pattern and processes of the natural world Specialists are imbibed with their own groups and tend to establish a consensus of what constitutes a species or a genus or whether it should be desirable to recognize sub species cultivars etc Ornithologists freely recognize subspecies and rarely do bird genera contain more than 10 species On the other hand some coleopterists and botanists work with genera with over 1500 species This asymmetry may reflect a biological reality it may express a working practicality or simply an historical artefact older erected genera often contain more species Rarely are these phenomena questioned

Prospects in Systematics D. L. Hawksworth, Systematics Association, 1988 This book critically reviews the developments and achievements of systematics in the 50 years since the foundation of the Systematics Association in 1937 and more particularly since the appearance of *The New Systematics* edited for the Association by Sir Julian Huxley in 1940 Botanists microbiologists palaeontologists and zoologists theoreticians and practitioners alike consider fundamental aspects of the subject and the directions in which it might develop into the next century The result is a description of a highly active subject adapting concepts and practices to accommodate exciting new information from expanding areas of research one which however also needs to take increased note of the requirements of its users The main challenge for systematics in the coming decades emerges as the need to re establish its central unifying position as the keystone of biology

The Evolution of Phylogenetic Systematics Andrew Hamilton, 2013-11-09 The Evolution of Phylogenetic Systematics aims to make sense of the rise of phylogenetic systematics its methods its objects of study and its theoretical foundations with contributions from historians philosophers and biologists This volume articulates an intellectual agenda for the study of systematics and taxonomy in a way that connects classification with larger historical themes in the biological sciences including morphology experimental and observational approaches evolution biogeography debates over form and function character transformation development and biodiversity It aims to provide frameworks for answering the question how did systematics become phylogenetic

Principles and Techniques of Contemporary Taxonomy Donald L.J. Quicke, 2013-03-13 Taxonomy is an ever changing controversial and exciting field of biology It has not remained motionless since the days of its founding fathers in the last century but just as with other fields of endeavour it continues to

advance in leaps and bounds both in procedure and in philosophy These changes are not only of interest to other taxonomists but have far reaching implications for much of the rest of biology and they have the potential to reshape a great deal of current biological thought because taxonomy underpins much of biological methodology It is not only important that an ethologist physiologist biochemist or ecologist can obtain information about the identities of the species which they are investigating biology is also uniquely dependent on the comparative method and on the need to generalize Both of these necessitate knowledge of the evolutionary relationships between organisms and it is the science of taxonomy that can develop testable phylogenetic hypotheses and ultimately provide the best estimates of evolutionary history and relationships

Foundations of Systematics and Biogeography David M. Williams, Malte C. Ebach, 2007-11-19 Anyone interested in comparative biology or the history of science will find this myth busting work genuinely fascinating It draws attention to the seminal studies and important advances that have shaped systematic and biogeographic thinking It traces concepts in homology and classification from the 19th century to the present through the provision of a unique anthology of scientific writings from Goethe Agassiz Owen Naef Zangerl and Nelson among others

Modern Concepts in Penicillium and Aspergillus Classification Robert A. Samson, John I. Pitt, 2013-11-11 In our view the First International Penicillium and Aspergillus Workshop held in Baarn and Amsterdam in May 1985 was a great success The assembly in one place of so many specialists in these two genera produced both interesting viewpoints and lively discussions But more particularly a remarkable cohesion of ideas emerged borne primarily of the realisation that taxonomy has passed from the hands of the solitary morphologist The future of taxonomy lay in collaborative and multidisciplinary studies embracing morphology physiology and newer methodologies Penicillium and Aspergillus Workshop was borne logically The Second International from the first and was held in Baarn on May 8-12 1989 It was attended by 38 scientists from 16 countries At this Workshop we have attempted to move further into new methods especially by bringing together molecular biologists medical and food mycologists and biochemists as well as more traditional taxonomists We feel that the meeting contributed greatly to dialogue between taxonomists and also fundamental and applied mycologists At the meeting we became aware that the approach to taxonomy of these genera is now becoming more pragmatic with an increasing emphasis on consensus and on stability of names This is a noteworthy development which we as editors welcome So many species in Penicillium and Aspergillus are economically important in biotechnology foods and medicine and practical stable taxonomy is of vital importance These Proceedings comprise 40 papers divided into 9 chapters

National Library of Medicine Current Catalog National Library of Medicine (U.S.), 1985

Current Catalog National Library of Medicine (U.S.), First multi year cumulation covers six years 1965-70

Classification of Mammals Malcolm C. McKenna, Susan K. Bell, 1997-10-17 Jean Louis Hartenberger Nature

Guide to Standard Floras of the World David G. Frodin, 2001-06-14 This 2001 book provides a selective annotated bibliography of the principal floras and related works of inventory for vascular plants The second edition was completely

updated and expanded to take into account the substantial literature of the late twentieth century and features a more fully developed review of the history of floristic documentation. The works covered are principally specialist publications such as floras, checklists, distribution atlases, systematic iconographies and enumerations or catalogues, although a relatively few more popularly oriented books are also included. The Guide is organised in ten geographical divisions with these successively divided into regions and units, each of which is prefaced with a historical review of floristic studies. In addition to the bibliography, the book includes general chapters on botanical bibliography, the history of floras and general principles and current trends, plus an appendix on bibliographic searching, a lexicon of serial abbreviations and author and geographical indexes.

Aspects of Tropical Mycology British Mycological Society. Symposium, Susan Isaac, 1993-11-25. Considers the role of fungi in the tropical ecosystem and their potential as a source of useful novel compounds.

Progress and Prospects in Evolutionary Biology Jeffrey R. Powell, 1997. The common fruitfly *Drosophila* is the most extensively studied of all organisms in genetical research. Thus it would appear to be the best model for achieving new insights. Its use in evolutionary studies has resulted in an explosion of knowledge which has never before been gathered into a single volume. This book spans the full range of evolutionary studies: population genetics, ecology, ecological genetics, speciation, phylogenetics, genome evolution, molecular evolution and development. In covering these topics, highlights of empirical research are emphasized and are put into the context of major issues in evolution.

Plant Systematics for the 21st Century Bertil Nordenstam, Gamal El-Ghazaly, Mohammed Kassas, 2000. This work provides a treatment of what is known about plant systematics, covering topics ranging from morphology to molecules. It provides insight into the biology and evolution of flowering plants as a whole.

The Plant Diversity of Malesia P. Baas, K. Kalkman, R. Geesink, 2012-12-06. Although the only publication with a realistic claim to the title, *The plant diversity of Malesia* is *Flora Malesiana* itself. We have hesitatingly chosen this title for the present proceedings volume. Past, present and future work on the *Flora Malesiana* project was the subject of a successful symposium held in August 1989. This book contains only a selection of the papers presented at that meeting, yet it covers a much greater diversity of themes than just the inventory of botanical diversity. It even goes beyond the boundaries of the vast *Flora Malesiana* region in several of its chapters. The role of the founder of the *Flora Malesiana* Project, Professor C. G. J. van Steenis, repeatedly recurs in several chapters, not only as director of and contributor to the project, but also as a pioneer in the fields of Malesian vegetation, conservation and biogeography, and as an enlightened systematist whose ideas and practical recommendations for taxonomic delimitation still largely apply. Botanical information made available in regional and local floras is of vital importance for applications such as the exploitation of natural forests on a sustainable yield basis for establishing gene banks for the benefit of agriculture, forestry and horticulture, and not in the least for nature conservation. Several chapters are devoted to these themes. Floristic studies are also at the basis of the biogeographical essays and vegetation studies included in this book.

Morphology, Anatomy, Taxonomy, and Ecology B. Zuckerman, 2012-12-02. Plant

Parasitic Nematodes Volume 1 Morphology Anatomy Taxonomy and Ecology is a masterful reference work in nematology that also includes information about ultrastructure enzymology and chemistry of body composition culturing virus transmission biological races and nature of plant resistance This volume includes a discussion of the history and development of plant nematology the status of research on this field and information pertaining to professional societies and publications It also discusses nematode morphology anatomy taxonomy and ecology including the origin of plant nematodes and population dynamics It features drawing examples of free living and animal parasitic nematodes This treatise is written to provide an up to date reference source for students lecturers and research professionals in plant parasitology specifically nematology and related fields

A Systematic Approach to Professional Selling ,

Termites: Evolution, Sociality, Symbioses, Ecology

Y. Abe,David Edward Bignell,T. Higashi,2014-11-14 The book is a new compendium in which leading termite scientists review the advances of the last 30 years in our understanding of phylogeny fossil records relationships with cockroaches social evolution nesting behaviour mutualisms with archaea protists bacteria and fungi nutrition energy metabolism population and community ecology soil conditioning greenhouse gas production and pest status

Issues in Ecosystem Ecology: 2011

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Nitrogen-fixing

Actinorhizal Symbioses Katharina Pawlowski,William E. Newton,2007-10-06 Nitrogen fixing Actinorhizal Symbioses This book is part of a seven volume series that was launched in 2004 and covers all aspects of nitrogen fixation from the biological systems to the industrial processes Volume 6 covers nitrogen fixing actinorhizal symbioses which occur between soil actinomycetes of the genus Frankia and a diverse group of dicotyledonous plants collectively called actinorhizal plants These symbioses play vital roles in native ecosystems as well as important components in both forestry and land reclamation The volume is divided into 11 chapters all authored by well known scientists in the field As in previous volumes of this series the first chapter presents an historical perspective and describes the development of actinorhizal research with its focus on the period after the first reproducible isolation of the responsible microorganism by John Torrey s group in 1978 Very early on the initial attempts to characterize the bacterium taxonomically had considered this endosymbiont as an obligate symbiotic bacterium and used its ability to form root nodules and its morphological characteristics within root nodule cells as

discriminative criteria to distinguish it from other actinomycetes. These efforts led to the emendation of the family Frankiaceae with the type genus *Frankia* and also to the definition of host specificity groups based on inoculation experiments using crushed nodules. However, after *Frankia* strains were isolated from nodules and pure cultures became available, many of these early results had to be discarded. Chapter 2 describes the techniques used to obtain phenotypic, genotypic and phylogenetic information on the members of the genus *Frankia*.

The Identification and Characterization of Pest Organisms D. L. Hawksworth, 1994. The identification of and relationship among pest organisms and their natural enemies is an essential prerequisite for the development of sustainable methods for their control. Biosystematics is the basis for management of biodiversity in sustainable agriculture. There is a vast armory of techniques available to the biosystematist and this book is the first major review of the applications and potential of the methods now in use, ranging from the morphometric and ultrastructural to isozymes and DNA sequencing. This volume consists of 34 papers presented at the Third Workshop on the Ecological Foundations of Sustainable Agriculture (WEFSA III) organized by CAB INTERNATIONAL and the Systematics Association, held in June 1993. The book is divided into four parts: biosystematic services, biosystematic information, biosystematic characters and biochemical and molecular biosystematics. It demonstrates how biosystematics can contribute to improved crop protection and which techniques are appropriate to address particular identification problems and makes recommendations for future actions.

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