Size and Shape

The discipline of biological morphometrics has had a reticulate evolution. From the 1960s until the early 1980s the term was generally held to be synonymous with numerical taxonomy or phenetics, the aim of which was to relate organisms objectively in terms of their overall similarity, assessed by measurements of body form and other quantitative traits. The basic tools for this purpose were those of exploratory multivariate statistics: principal-component and factor analysis for describing and decomposing patterns of variation, discriminant analysis for distinguishing among taxa and assessing their differences, and cluster analysis for creating nested subsets of organisms that were interpreted as hierarchical evolutionary lineages. Many of the morphometric techniques still in common use were borrowed from other disciplines, particularly social science and psychometrics, and applied directly to traits of organisms with little regard for the quality or importance of the measurements themselves. This tradition provided no guidelines for selecting traits to be studied other than that they be quantitative, be numerous, and sample the whole form.

Biological morphometry has progressed significantly in the past ten years, however, owing primarily to the infusion of a geometric perspective on form and to a renewed emphasis on explicit assumptions about anatomical homologies and on allometric models of growth and size-variation. Such models and assumptions are necessary for biological comparisons (as opposed to purely statistical contrasts) because they furnish a firm biological context within which to interpret results. The emphasis on geometric aspects of form dates back to the seminal work of D'Arcy Thompson, the father of the deformation grid, which graphically depicts the point-for-point geometric transformation of one form onto another. Quantification of this and other graphical techniques (such as median axes) and their more recent synthesis with confirmatory multivariate statistics have produced a powerful, rapidly developing methodology for exploring the diversity of organic form.

This volume, which is firmly grounded in the "new morphometric synthesis," is one of the fruitful products of an NSF-sponsored workshop held in 1988 at the University of Michigan. (A second workshop on morphometrics occurred in 1990 at Stony Brook, and the third in the series recently took place at the Centro Nacional de Educación Ambientales en la Naturaleza, in Segovia.) The book comprises 21 chapters by 19 authors. It begins with an introduction outlining the purposes and outcome of the workshop and a survey of the available analytic software, much of which can be purchased on an accompanying set of floppy disks. This is followed by several chapters on the technology of acquiring digitized images and deriving data from them. As Rohlf notes, the wide and reasonably inexpensive availability of computerized image-analysis systems has greatly stimulated theoretical and applied research in biological morphometry, and digitized images are increasingly used for archival documentation and publication as well as for data collection.

The heart of the volume is the third part: a series of detailed and generally comprehensible discussions and applications of various analytic methods. It is divided into sections on traditional multivariate procedures; on boundary methods for the description of silhouettes and other projections (here a recurring theme is apology for the lack of landmarks); and on methods for landmark data (configurations of anatomical points abstracted from the organisms of interest and assumed to be homologous, or at least comparable, among forms). Preceding these sections is an excellent overview by Bookstein, heavily biased toward his own perspective and contributions but placing the alternate approaches within a common comparative context. This overview, coupled with Bookstein's introduction to methods for landmark-based data, forms a solid philosophical approach to morphometrics around which the remainder of the volume is constructed and contrasted. These chapters in particular are valuable reading for all who apply morphometric methods in their work.

The analytic chapters, though technical, are not necessarily dull reading; many gems of information and opinion are to be found along the way. For example, several chapters emphasize that, although many superficially distinct methods have common analytical bases, they were originally developed independently by mathematicians working within different intellectual traditions and using different notations. Marcus, for example, describes the development of path models and path analysis by Sewall Wright parallel to the elaboration of factor analysis by social scientists after Spearman and Hotelling. Bookstein contrasts the classical context for which least-squares methods were developed (the estimation of physical constants in celestial mechanics and geodesy) with their use in biometric regression, in which exact physical laws were replaced by the "vague notions" of genetic and evolutionary causality. And Reyment relates the interesting parallel and contemporary developments at the hands of Fisher (on distinguishing species using multivariate data), Mahalanobis (on measuring multivariate distances), and Hotelling (on testing whether multivariate samples differ non-randomly) that led to our modern formulation of the linear discriminant function. The algebraic connections between these latter procedures are straightforward but the correspondences were not recognized until long after many "chauvinistic polemics" had taken place.

The fourth part of the book goes beyond the detailing of analytic methods to the extremely important "problem of homology." Although the applications of morphometric descriptions and comparisons span many disciplines, the context for the workshops and proceedings is proclaimed to be evolutionary systematics. Given the central role of cladistics in contemporary systematics, perhaps the main point of discussion lies in Smith's chapter on the relationship between morphometrics and phylogenetic inference. The power of morphometrics comes from the precise description and delimitation of characters that quantification makes possible, and thus it is playing an increasingly important role in phylogenetic inference, which, despite its logical rigor, has been based primarily on conventional qualitative characters. The issues of homology and primitive vs. derived similarity are fundamental to phylogeny reconstruction. Smith summarizes very well the current attitudes and approaches, but much more needs to be done to strengthen the connection between morphometrics and phylogenetic systematics.

Altogether this is an impressive and important book. It is not without its deficiencies, both functional—lack of index, poorly produced and paginated figures and tables, redundancy of literature citations—and methodological, such as the insufficient emphasis on allometry and other biological models and on the use of continuous characters in phylogenetic inference. Nevertheless, the volume will allow the biologist with a modicum of quantitative background to gain an understanding of the methods, problems, and philosophies of morphometrics. It should be widely read and extensively cited.

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