Chapter 1

Introductory Chapter - Morphometric Studies: Beyond Pure Anatomical Form Analysis

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Morphometrics (or morphometry)[1] refers to the study of shape variation of organs and organisms and its covariation with other variables [1]: "*Defined as the fusion of geometry and biology, morphometrics deals with the study of form in two- or three-dimensional space*" [2]. *Shape* encompasses, together with *size*, the *form* in Needham's equation (1950) [3], two aspects with differing properties.

Scientific production in the morphometric field has increased dramatically over the last few decades. I do not doubt that largely this has resulted from easily available and (usually) fairly comprehensive computer programs, cheaper and more powerful personal computers, and more specialized and less expensive equipment for raw data acquisition: "*Fortunately, the morphometric community is replete with theorists who also generate software, and thus numerous packages are available*" [4].

Therefore, in addition to the "classical" tools for obtaining data (such as images), there is currently a wide spectrum of very advanced technology available, making measurements of any type easier, with more resolution, three-dimensional, less invasive and more complex: computed tomography, magnetic resonance imaging, ultrasound, surface scanners and other three-dimensional data-collection devices, scanners.[2] An example of this "new technological age" is the estimation of body surface area (BSA). The estimation of BSA can be traced back to 1793, when Abernathy directly measured the surface area of the head, hand, and foot in humans using triangular-shaped paper, estimating the remaining segments of the body using linear geometry [5]. Similarly in animals, initial BSA data were obtained by pasting strips of strong manila paper, gummed on one side, to the hair of the animals [6] or rolling a revolving metal cylinder of a known area, attached to a revolution counter [7]. Recently, however,

[1]From the Greek μορφή, *morphe*, meaning "form", and –μετρία, *metria*, meaning "measurement." The term "morphometrics" seems to have been coined in 1957 by Robert E. Blackith from Dublin University, who studied the subject in relation to locusts [1].

[2]No single type of imaging is always better; each has different potential advantages and disadvantages, and obviously their interpretation is subject to the hypothesis at hand.

complex techniques, such as computed tomography have been applied [8], and these have undoubtedly improved the quality (precision, ease) of data (and, frankly, I cannot imagine a live ferret being wrapped in a sheet of paper to estimate its BSA!).

A personal comment is in order here. These considerations have not been developed according to any deeper theoretical considerations. They are mainly based on personal experience of working with morphology in different contexts. Their aim is to provide an intuitive overview of how and for what purpose morphology can be applied, rather than attempting to formulate a strict thesis. Perhaps, needless to say, this is a text aimed at presenting certain personal ideas about morphometrics and morphology, not an attempt to give an exhaustive presentation of the literature on the topic. The bibliography presented is simply for things to make more sense and to demonstrate how I justify some assumptions on conceiving the ideas set forth.

Let us continue. Current software for morphometry can analyze data whatever their origin, and normally, it allows the construction of relevant images (the role of visual representations is very important in morphometrics, although algorithms sometimes cannot show completely accurate results, for instance, because they are not well adapted to a discrete framework).

Morphometrics was initially performed on organisms (*"Morphometrics is simply a quantitative way of addressing the shape comparisons that have always interested biologists"*) [9], extracting information by means of mathematical operations. Tools of morphometrical methods initially applied to study merely form (size + shape)[3] can be applied to other nonbiological fields. In this context, "morphometrical analysis" refers to the analysis of form within the particular scientific discipline where this term is used, including nonbiological forms. Many of the morphometrical concepts can, however, be generalized to encompass nonbiological hypotheses, and their applications are not currently restricted to biological uses. We now therefore have many branches of morphometrics which have emerged as a praxis of their own, such as "geomorphometry" [10] and "archaeometry" [3]. For a wider vision of morphology applications, it is recommended to read Zwicky's publications, which are listed on the website of The Fritz Zwicky Foundation (FZF) at: http://www.zwicky-stiftung.ch/index.php?p=6|8|8&url=/Links.htm. Furthermore, current morphological mathematical tools have similar advantages when applied to the study of "other-than-form" traits: color [11], pigmentation patterns, textures, etc. This is also the case when applied to meristic (countable) characters (for instance, fin rays in fish, cephalic foramina in skulls, etc.).

With this availability of many computational facilitations and so wide a spectrum of applications, current morphometric research cannot simply be applied to such a wide range of fields, but also requires the combination of many disciplines. All of these factors add up to a complex task, which should not be beyond our power as ordinary scientists. Morphometrics increasingly calls for an integrative research approach, in addition to a good understanding of the mathematical or logical basis of the approach considered.

In summary, we can give many answers based on any motivation of measurement, not only form, the *morphé*, on biological bodies. The important question in morphometrical analyses is frequently more related conceptually to how and what we measure than to how we should

[3]*Shape* contains the whole geometry (i.e., proportions) of objects, but it does not always take into account the overall complexity of the geometry of the specimens [3].

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proceed mathematically. For instance, same samples measured by means of geometric morphometrics or lineal morphometrics show totally different results, although statistical multivariate analyses are similar (comparing, for instance, [12, 13], it is clear how results can change according to a mere difference in how crude data were obtained (obviously I refer to technique, not quality)).

Morphology[4] "*refer*(s) *to the study of the structural relationships between different parts or aspects of the object of study*" [14]. It therefore includes aspects of outward appearance (shape, size, structure, color, pattern, i.e., external morphology or eidonomy), as well as the form and structure of the internal parts, like bones and organs, that is, internal morphology (or anatomy)[5]. Not only internal traits but also other external traits can therefore be mathematically analyzed with morphometric methods. We then have a huge cloud of research in a completely morphological—rather than merely morphometrical—field: biological or nonbiological specimens, on form or more structural traits, etc. For instance, in a study of mine of 322 eggs belonging to different Catalan hen breeds and varieties (data unpublished but available upon request from the author), the mere analysis of shape (using 3 classic descriptors "egg surface", "egg volume" [15], and "shape index" [16]) allowed 3.7% of correct identifications. When the analysis included fresh weight (which could be interpreted as size), they increased to 18.0%; and when the traits studied included color (cream or tinted, white or brown), successful classification reached 20.8%. This is just an example of how results can be obtained by means of a production process—in some cases, a complex one—but which will be influenced by decisions on the hypothesis taken rather than by the mathematic algorithms concerned.

In conclusion, morphometrics, being a branch of statistics, must be viewed as a branch of morphology in the widest sense.[6] Also, on emphasizing the broad component of morphology, we do not rule out the significance of its mathematical component.

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References

[1] Reyment RA. Morphometrics: An historical essay, In: Elewa AMT, editor. Morphometrics for Nonmorphometricians, Lecture Notes in Earth. Vol. 124. Springer-Verlag Berlin Heidelberg

[4]From the Ancient Greek *don*, *morphé*, meaning "form," and λόγος, *lógos*, meaning "word, study, research".
[5]From the Ancient Greek ἀνατομή, *anatomē*, meaning "dissection", and –τέμνω, *témnō*, meaning "I cut".
[6]And with morphometric technique being dependent on images, would it be better defined as "morphography"? I leave it to the readers' consideration.

[2] Richtsmeier JT, DeLeon VB, Lele SR. The promise of geometric morphometrics. American Journal of Physical Anthropology. 2002;**45**:63-91

[3] Borel A, Cornette R, Baylac M. Stone tool forms and functions: A morphometric analysis of modern humans Stone tools from song terus cave (Java, Indonesia). Archaeometry. 2017;**59**(3):455-471

[4] Adams DC, Rohlf FJ, Slice DE. A field comes of age: Geometric morphometrics in the 21st century. Hystrix. 2013;**24**(1):7-14

[5] Daniell N, Olds T, Tomkinson G. Technical note: Criterion validity of whole body surface area equations: A comparison using 3D laser scanning. American Journal of Physical Anthropology. 2012;**148**(1):148-155

[6] Hogan AG, Skouby CI. Determination of the surface area of cattle and swine. Journal of Agricultural Research. 1923;**25**(419):419-432

[7] Elting EC. A formula for estimating surface area of dairy cattle. Journal of Agricultural Research. 1926;**33**(3):269-280

[8] Jones KL, Abbigail Granger L, Kearney MT, da Cunha AF, Cutler DC, Shapiro ME, Tully TN, Shiomitsu K. Evaluation of a ferret-specific formula for determining body surface area to improve chemotherapeutic dosing. American Journal of Veterinary Research. 2015;**76**(2):142-148

[9] Zelditch ML, Swiderski DL, Sheets HD. Geometric Morphometrics for Biologists: A Primer. Boston, MA : Elsevier Academic Press; 2004

[10] Guth PL. Drainage basin morphometry: A global snapshot from the shuttle radar topography mission. Hydrology and Earth System Sciences. 2011;**15**(7):2091-2099

[11] Hall-Spencer JM, Moore PG, Sneddon LU. Observations and possible function of the striking anterior coloration of Galathea intermedia (Crustacea: Decapoda: Anomura). Journal of the Marine Biological Association UK. 1999;**79**:371-372

[12] Parés-Casanova PM, Morros C. Molar asymmetry shows a chewing-side preference in horses. Journal of Zoological and Bioscience Research. 2014;**1**(1):14-18

[13] Parés-Casanova PM, Reig E. Directional and fluctuating asymmetries in Cavall Pirinenc Català breed molars. Journal of Animal Ethnology. 2015;**1**:10-18

[14] Álvarez A. Ritchey T. Applications of General Morphological Analysis. Acta Morphologica Generalis. 2015;**4**(1):1-40

[15] Havlíček M, Nedomová Š, Simeonovová J, Severa L, Křivánek I. On the evaluation of chicken egg shape variability. Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis. 2008;**56**(5):69-74

[16] Altuntas E, Sekeroglu A. Effect of egg shape index on mechanical properties of chicken eggs. Journal of Food Engineering. 2008;**85**(4):606-612