The Status of Taxonomy of Mosquitoes by the Use of Morphological Characters

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The title of this symposium is "Mosquito Taxonomy - Is it needed?" and my role on the program is to defend the use of morphological characteristics to recognize species.

Before proceeding with the defense, I would like to examine the level of sophistication of mosquito taxonomy in order to answer the question of whether mosquito taxonomy is needed or not.

The classification of any group of organisms passes through three overlapping yet more or less distinct phases that are commonly referred to as alpha, beta, and gamma taxonomy. In the first or "alpha taxonomy" phase, emphasis is on finding and describing species and provisionally arranging them in comprehensive genera. Typical publications of this phase are descriptions of new species and catalogs of nominal species. In the second or "beta taxonomy" phase, emphasis is on arranging the species in a good natural classification. Typical publications of this phase are revisions and monographs. In the third or "gamma taxonomy" phase, emphasis is on interpreting the diversity within a group. Typical publications of this phase are, for example, genetic or ecological studies that attempt to explain intra- and interspecific variations.

I believe that mosquito taxonomy is, in general, still in the alpha phase. Vast numbers of undiscovered and unrecognized species still exist and the known species are placed in relatively few comprehensive genera. The underlying taxonomic knowledge of mosquitoes is so incomplete that it is not possible to identify correctly even the common species in many groups and in many regions of the world and it is not possible to predict accurately unknown features of the known species from the existing classification. Additional evidence that mosquito taxonomy is still in the alpha phase is that one of the most useful publications in the field is the Synoptic Catalog by Stone, Knight, and Starcke (1959). At the present time I believe we are witnessing a definite major movement toward the beta taxonomy phase, for in the past few years the "first generation" of detailed revisions of several groups of mosquitoes for the Middle American and Southeast Asian areas have been published. Now, of course, not all groups within a larger taxonomic group pass through the three phases of classification at the same rate and there are several species groups of mosquitoes, as for example in the genus *Anopheles* and the subgenus *Stegomyia* of *Aedes*, where the taxonomy may be considered to have reached the gamma phase of sophistication.

The answer to the question of whether mosquito taxonomy is still needed is very obviously an emphatic "yes" when the level of maturation of the classification of mosquitoes is compared with the phases that the classifications of other groups pass through.

I will now proceed with the defense of the use of morphological characters instead of genetic, ecological, physiological, biochemical, or ethological characters to recognize species of mosquitoes. I believe the best way to defend the use of morphological characters for this purpose is to outline the methodology used in a comparative morphological taxonomic study and then to examine this methodology in the light of the modern concept of the species.

Modern comparative morphological revisions of mosquitoes are based on the very careful examination of the external anatomy of all stages in the life cycle, that is, larvae, pupae, adults and sometimes even eggs, that have been definitely associated with each other by individual or progeny rearings, for a large series of specimens from as many populations as possible from throughout the range of the group. It should be pointed out that the examination of adults with unequivocally associated immatures permits the correlation of small yet possibly taxonomically significant differences in one stage with those in another stage, that the examination of large series of specimens from one population gives an estimate of the amount of variation that can be expected in a local population, and that the careful examination of populations from the entire range gives an estimate of the amount and kind of variation that may occur among populations. This background knowledge of the amount and kind of intra- and interpopulational variation that can be expected in a particular species or group becomes an invaluable tool for gauging the degree of reproductive isolation of the various populations on the basis of morphological evidence. After the initial careful examination of the material, species are recognized, at least tentatively, on the basis of constantly correlated morphological features from all stages. These species are then arranged into a classification on the basis of their phenotypic similarity and inferred genealogy. In the final interpretation of the species and higher taxa, ecological, geographical, and any other data that are available are taken into consideration.

Now I will examine this methodology in the light of the modern concept of the species. The most widely accepted definition of a species is that of Mayr (see Mayr, 1963: 19), which states that "Species are groups of actually or potentially interbreeding natural populations which are reproductively isolated from other such groups." This definition correctly emphasizes the more or less complete reproductive isolation of contemporaneous biparental species of organisms. Because of this reproductive isolation, each species has a unique genotype that is expressed phenotypically as a unique set of morphological, ecological, physiological, biochemical, and ethological characteristics. Reproductive isolation cannot be observed in museum specimens and, if for no other reasons than practical ones, the reproductive isolation of the great majority of known species has not been tested by observation or experimentation with living organisms at the present time. However,

as Mayr (1969: 27-29) and Simpson (1961: 68-77; 150-152) have pointed out, the reproductive isolation of the genotypes of species can be reliably and legitimately inferred from discontinuities in the phenotypic expression of these genotypes. In other words, the evidence that the so-called biological or genetical species definition is met in a particular instance may be morphological, ecological, physiological, biochemical, or ethological. It follows that since most of these types of evidence cannot be observed in museum specimens, taxonomists must by necessity rely heavily upon morphological evidence of reproductive isolation in most groups of organisms at this time.

Now, why do I personally use the comparative morphological approach in my studies of mosquitoes? First, because I firmly believe that the great majority of mosquito species can be accurately recognized on the basis of their constantly correlated morphological characteristics, particularly when these characteristics are drawn from all stages of the life cycle and when they can be evaluated by a good understanding of the intra- and interpopulational variation in the group. Second, because I believe the existing taxonomy in most groups of mosquitoes is so poor that careful comparative morphological studies must be done in order to discover and define problems that need to be examined in the light of evidence from non-morphological data or that can be resolved only by experiment and observation on living organisms in the laboratory and field. Third, because I believe only those taxonomic studies that are based on or at least include a careful comparative morphological study can provide the in depth knowledge of the morphological characteristics of the species that it takes to produce reliable keys for the use of other biologists whose work may require the accurate identification of specimens. Fourth, for the practical reason that the only type of evidence that can be used to infer the reproductive isolation of populations that has been consistently and systematically accumulated and that can be assembled for comparative studies is the morphological data that can be derived from museum specimens. Fifth, for the practical reason that the comparative morphological approach is the fastest means of recognizing species and arranging them into a classification. And finally, for the practical reason that I am geographically isolated from the Neotropical fauna I work with and therefore do not have quick and ready access to living material.

In closing, let me point out that although I have defended the use of morphological characters to infer the reproductive isolation of populations, I have not denied that non-morphological data can be used to achieve the same end, and, in fact, I believe that non-morphological data are always desirable and valuable supplements to morphological data and are often necessary to resolve taxonomic problems.

References

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