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Systematics and Taxonomy

1. Introduction

Systematics may be defined as the study of the kinds and diversity of organisms and the relationships among them. Taxonomy, the theory and practice of identifying, describing, naming, and classifying organisms, is an integral part of systematics. Classification is the arrangement of organisms into groups (*taxa*, singular *taxon*) on the basis of their relationships. It follows that identification can take place only after a classification has been established. It should be emphasized that not all authors adopt these definitions. Taxonomy is often used as a synonym of systematics (as defined above), while classification is sometimes used rather loosely (and incorrectly) as a synonym of identification.

Systematics is an activity that impinges on most other areas of biological endeavor. Yet, its importance (and fiscal support for it) seem to have diminished in recent years. To some extent, this may be the fault of systematists who tend to work in isolation, often focusing on some small and obscure group of organisms. This may be especially true of entomological systematists who, faced with the enormous diversity of the Insecta, tend to be seen as "counters of bristles," "measurers of head width" and performers of other activities of little relevance to the outside world. In fact, as Danks (1988) elegantly pointed out, nothing could be further from the truth. Systematics has played, and continues to play, a major role in fundamental evolutionary and ecological studies, for example faunistic surveys, zoogeographic work, life-history investigations and studies of associations between insects and other organisms. In applied entomology good systematic work is the basis for decisions on the management of pests. Indeed, Danks (1988) provided examples of pest-management projects in which inadequate or faulty systematics resulted in failure, sometimes with great economic and social cost (and see Section 2).

The taxonomy of insects, like that of most other groups of living organisms, continues to be based primarily on external structure, though limited use has also been made (sometimes of necessity, especially between species) of physiological, developmental, behavioral, and cytogenetic data. Molecular biological analyses of problems in insect systematics have increased exponentially over the past two decades (Caterino *et al*., 2000). These analyses, principally using mtDNA sequences, have principally focused on the resolution of relationships at lower taxonomic levels, for example, among subspecies, species and species groups. Molecular phylogenetic studies of higher insect taxa (e.g., relationships among

orders), though far fewer, have nevertheless generated important, sometimes even controversial, conclusions (see Chapter 2 for examples).

The purpose of this chapter is to provide a short introduction to the systematics of insects, including some of the technical terms applied by workers in these fields, as a basis for Chapters 5–10 inclusive, which deal with individual insect orders.

2. Naming and Describing Insects

For a variety of reasons but most obviously the enormous diversity within the class Insecta and economic considerations, insect taxonomists usually work within fairly narrow boundaries. Only by doing this can they acquire the necessary familiarity with a particular group (including knowledge of the relevant literature) to determine whether the specimen they are examining has been described and named or may be new to science. Even after a particular group has been chosen for study, there are typically superimposed biogeographic constraints, that is, taxonomists restrict their studies to particular geographic regions.

Many frequently encountered insects, especially pests, have a "common name" by which they are known. The name may refer to a particular species (e.g., house fly) or to a larger group (e.g., scorpionflies) and reflects a characteristic feature of the insect's appearance or habits. Unfortunately, insects of widely different groups may have similar habits (e.g., so-called "leaf miners" may be larvae of Diptera, Lepidoptera, or Hymenoptera) or the same common name may refer to different species of insects in different parts of the world. Thus, to avoid possible confusion, each insect species, like all other organisms both fossil and extant, is given a unique latinized binomial (two-part) name, a system introduced by Linnaeus in the early 1700s. In the Latin name, which is always italicized, the first word denotes the genus, the second the species (e.g., *Musca domestica* for the house fly). Rarely, the name has three parts, the third indicating the subspecies. (It should be noted, however, that some national entomological societies such as those of the United States and Canada publish lists of the *approved* common names for species in order to allow their use, yet avoid possible misunderstanding.)

Species are normally distinguished on the basis of a small number of key features (*characters*) that exist in a specific *character state* in each species (e.g., "number of tarsal segments" is a character, and "five tarsal segments" is a character state). Thus, a taxonomist will base the description of a new species on the characters already established for other species in the same group to facilitate comparison with them. Careful collection and curation (preparation, preservation, and maintenance) of specimens are critical to taxonomy to ensure that potentially important characters (which may be minute and delicate) are not damaged. The specimens must be properly labeled with the date and place of collection (preferably using map coordinates) and the collector's name. To facilitate proper maintenance, as well as accessibility for further studies, specimens are usually submitted to a central repository, the name of which is included in the published description of the species, to become part of the reference collection.

The specimens whose description leads to the establishment of a new species form the *type series*, one only of which becomes the standard reference specimen, the *holotype*, the others in the series being *paratypes*. The name given to a new species must follow the rules and universal nomenclatural system laid down by the International Commission on Zoological Nomenclature (published in the International Code of Zoological