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Discourse on the classification of the Scale Insects

With the current controversy regarding the classification status of the species assigned to the orders Hemiptera and Homoptera, stability within the placement of the scale insects is a worthy effort with few serious attempts in the past to determine a classification strategy. The primary goal for any classification scheme should be to adopt one that is not only simple, elegant, and usable, but has the highest degree of accuracy for the identification of the related taxa included. The primary means for determining the higher categories of orders in modern insect taxonomy is based on the wing structure and development as evidenced by their epithet. Taxonomists since Aristotle have attempted to classify organisms into categories based on morphological similarities. Such grouping allowed for the development of the logical hypothesis that the greater the degree of morphological similarity, the closer the affinity between two independent taxa. Agreement on the question of which hierarchy scheme to adopt and the appropriate placement of the scale insects would contribute to the overall stability of the higher categories.

A number of variations in the classification of the higher levels is prevalent. There is the current trend by many taxonomists to include those estimated 80,000 species (Dolling, 1991) once separated into the Orders Hemiptera and Homoptera into one Order (Hemiptera) that itself is divided into the suborders, Auchenorrhyncha, Coleorrhyncha, Gymnocerata, Heteroptera, and Sternorrhyncha. Others include the species in one Order (Hemiptera); itself divided into two suborders, the Heteroptera (true bugs) and the Homoptera (Sternorrhyncha and Auchenorrhyncha) based principally on wing structure and location of the beak. One major concern resulting from these classification proposals is that the Order name (Hemiptera = half, wing) would no longer accurately reflect all the species groups included.

Some perceive no need to revise the higher categories of Hemiptera and Homoptera viewing the consistent structures distinguishing species within these two taxa to be more numerous and stable than those used to identify most other higher categories (i.e., Psocoptera, Blattaria, etc.). They also point to the well-known fossil records for specimens collected from around the world. The Homoptera are known to have been a highly developed Order by the Lower Permian era with indications that the Order

may well have been established in the Carboniferous era (Carpenter, 1930). He proposed that the Hemiptera (Heteroptera) on the other hand was present in the Triassic era with the probability that species existed as early as the Permian era. Although several have postulated that all major feeding types were present before the ascendance of the angiosperms, Danzig (1980) concluded the scale insect developed into the various family groups upon the emergence of angiosperms in the Upper Carboniferous era.

Another general proposal from current investigations suggests that the homopterans may be a paraphyletic group with Sternorrhyncha representing a sister group to a group comprising the Auchenorrhyncha and the Heteroptera; and thus, constituting the necessity for a revision of the classification system for Homoptera and Hemiptera (Sorensen *et al.*, 1995; von Dohlen & Moran, 1995). This concept is supported by several investigators, primarily based on modern DNA analysis using base pairs of 18S ribosomal DNA sequenced to apply molecular characters to assess Homoptera phylogeny (Campbell *et al.*, 1994).

The distinctive morphological characteristics of species shared within the two orders do have distinguishing components. The major morphological traits that distinguish species within the Hemiptera include: forewings half leathery-like and half membranous, wings held flat over body, a large pronotum, smaller mesonotum and metanotum compared to body size, 4-5 segmented antennae; 2 or 3 ocelli usual present in addition to compound eyes; piercing/sucking mouthparts with the mandibles and maxillae forming 2 pairs of piercing stylets contained in a flexible 3- or 4-segmented beak derived from the labium and arising from the hind part of the lower side of the head, tarsi with 3 or fewer segments, and antennae 4-5 segmented. Other characteristics distinguishing hemipterans from homopterans include some aquatic, parasitic, disease vectors, and species with scent glands.

All homopterans feed on plants and are characterized by membranous or textured forewings often held in a tent-like fashion over their body, a small pronotum, a large mesonotum, and slightly smaller metanotum. The proboscis is shorter than that found in true bugs, and the mouthparts emerge near the ventral posterior margin of the head. Most species have a portion of their digestive system modified into a filter chamber that allows for ingestion and processing of vast quantities of plant sap. The excess water, sugars, and amino acids bypass most of the midgut and are shunted directly into the hindgut for excretion as honeydew.

In addition to the development, behavioral, and host range elucidated for species comprising the higher taxa, the wing venation also supports the supposition that the two orders represent separate entities. Although wing venation within the Hemiptera and Homoptera are similar, there are significant and distinctive differences. Indeed, hemipteran species have a similar vein system, with the exception of the cubitus vein being unbranched in the hind wing. However, the hemipterans have retained the vannal fold lying between the medial and anal vein in the hind wing, while it crosses the anal vein in homopterans. In addition, the absence of a subcostal vein and the presence of

a double (or fused) vein in the tegminal area are major traits in most homopterans.

While species are genetically unique, higher taxa are merely abstract concepts, and although based on physical traits, are within the realm of subjectivity by the observer. The overriding goal is to provide a means of classifying a new or undetermined species by determining the unique traits that can be used to differentiate it from other similar species. With the development of the modern classification design, organisms are arranged into groups on the basis of homologies or relationships; the concept of which is consistently reinforced by innumerable tests by modern taxonomists and systematists (Simpson, 1961, Schaefer, 1996). The basic tenet is that such taxa of any higher level composed of distinct organisms may be considered a definite category. While the number of levels between taxa is not prohibited by the International Code, common sense should prevail to omit any that do not contribute to the overall objective of defining and identifying the organism in question. All to often, higher category levels are introduced (i.e., infraorder) without substantial evidence of need or adequate explanation as to why the level is proposed by the author.

In regard to the position and classification of the scale insects, Dr. Michael Kosztarab has offered the challenge to discuss and come to a consensus on the usage of the possible categories of: superfamily name Coccoidea, the suborder name Coccinea, and the proposed Order name Coccura. Based on morphological assessments of the body (i.e., mouthparts, etc.), development, etc., and now DNA analysis, one may conclude that the scale insects are definitely a homogeneous group. The levels or ranks, while not prohibited by zoological rules or standards, require consideration of the identifier. Consider that for each rank included, the taxonomist is required to remember each of the positions for each species. Regardless of the classification structure adopted, the specific groups will and should remain together.

The superfamily Coccoidea has been used since the name was proposed by Theron (1958), and is recognized by both the scientific community and public at large. Currently, 22-27 families are generally recognized within the superfamily Coccoidea. Over the past half-century, various names have been proposed to represent the scale insect groups. The highest formal rank proposed for the assemblage of mealybugs and scale insects is that of suborder Coccinea (Koteja, 1974; Danzig, 1980), while Kosztarab has suggested that we consider Order rank for the scale insects. However, most scale insect taxonomists accept the premise that the superfamily level name, Coccoidea, suitably accommodates the included taxa at this time. Koteja has projected that there may come a time, as more knowledge is obtained, that a higher category level may be required to effectively differentiate the groups. Should a revised classification be adopted, the use of a superfamily level for the scale insects would be in keeping with that proposed for the other species groups included within the suborders to maintain consistency and simplicity.

In the suborder Coccinea alluded to by Koteja (1974), the two superfamilies included are: Orthezioidea that is equivalent to Archaecoccoidea of some authors, and Coccoidea, which constitutes a lesser rank than the superfamily level and is used as

an equivalent of Neococcoidea. He correctly concluded that this arrangement led to a degree of confusion by those who wished to obtain a better understanding of the group. The use of such taxonomic levels (Archeococcoidea and Neococcoidea) to artificially separate the scale insects is perceived to refer to a general division rather than a formal one. An interesting concept for consideration is that Orders are denoted base on specific traits for the taxon, while general grouping are often determined by development. A great opportunity exists to procure a consensus of usage by this assemblage of scale insect workers.

At least five higher category designs have been recently proposed that include the scale insects. Each provides a degree of stability for the included species based on morphological and developmental data. However, there appears to be a growing trend by most taxonomists to recognize only Hemiptera as the taxon to incorporate all species previously included in the two Orders Homoptera and Hemiptera. While I would prefer we retain the current classification scheme of separating the insect groups into the two orders (Homoptera and Hemiptera), I do not see significant problems arising from the adoption of Hemiptera. My general preference is based primarily upon the perception of "best fit" for the included species taxa. Interestingly, many of the major concerns regarding placement of family and generic groups arises at the suborder rank. Perhaps the selection of a classification scheme to include the scale insects may not be uniformly accepted by workers for decades. Nevertheless, we must eventually adopt a system that will be widely accepted and understood by workers to provide the confidence and stability required to advance future studies on these important insect species.

Key words: Homoptera-Hemiptera, classification, insect categories

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