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### The case for using the infraorder Cocomorpha above the superfamily Coccoidea for the scale insects (Hemiptera: Sternorrhyncha)

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The order Hemiptera was formerly divided into two suborders, Heteroptera and Homoptera. The suborder Homoptera was also divided into two convenient groups, the Auchenorrhyncha and the Sternorrhyncha, the latter comprising the superfamilies Aphidoidea, Psylloidea, and Aleyrodoidea, plus the scale insects in the superfamily Coccoidea. Until about the mid-20th century, most workers on scale insects were content to place the scale insects in the family Coccidae but, with the ever-increasing number of subfamilies being raised to family rank, the superfamily rank Coccoidea came into general use. There are now 49 families presently recognised in the scale insects (Ben-Dov *et al.*, 2014) including families based on fossils. In a recent publication by Kozár *et al.* (2013), family-group names for two families were resurrected and a new name for a new family was discussed, increasing the number of possible family-group names to 52.

Balachowsky (1942) proposed that the Coccoidea be divided into three high-rank groups (which he confusingly called “phyla”): the Orthezioidea, Lecanioidea and Phenacoleachioidea, but these ranks have never been accepted. Superfamilial ranks are not new in the scale insects. For instance, the following have been proposed: Diaspidoidea, Lecanioidea and Margarodoidea by Obenberger (1957); Orthezioidea and Pseudococcoidea by Chou (1963), and the Coccoidea by Handlirsch (1903). Some workers, mainly in eastern Europe (e.g., Koteja, 1974a b; Danzig, 1980; Kosztarab & Kozár, 1988), have used the rank Coccinea above that of superfamily rank.

Formerly, many scale insect workers divided the scale insects into two groups, the superfamilies Orthezioidea and Coccoidea (e.g., Koteja, 1974a, b; Danzig, 1980). However, currently, the superfamily Coccoidea is more frequently divided into two informal groups, the archaeococcoids and the neococcoids, but there are differences of opinion as to the limits and family placement within each group. This division into these two informal groups was discussed by Gullan and Cook (2007), who showed that some of the Coccoidea that look similar morphologically were not closely related, and Hodgson and Foldi (2006) and Hodgson and Hardy (2013), based on studies of adult male morphology, considered that this division into two groups was too simplistic.

Heslop-Harrison (1952) argued that the two suborders, Heteroptera and Homoptera, were established and recognised purely for convenience and that there was no real distinction based on morphological characters. He stated that the only difference between them was that the Heteroptera differed from the Homoptera in having a gula, which is absent in the Homoptera. He also proposed the establishment of eight natural groups within the Hemiptera, including the rank of Coccidomorpha for the scale insects and the names Aleurodomorpha (Aleyrodomorpha), Aphididomorpha and Psyllidomorpha for the other sternorrhynchan groups and Peloridiidomorpha (Coleorrhyncha), Fulgoridomorpha, Cicadidomorpha and Jassidomorpha for family groups within the Auchenorrhyncha. Earlier, Evans (1946) had proposed the names Fulgoromorpha, Cicadomorpha and Jassidomorpha for the leafhoppers within the Auchenorrhyncha. Not all of the groups suggested by Heslop-Harrison have been accepted.

Based on phylogenetic analyses, Campell *et al.* (1995) suggested that the Auchenorrhyncha are more closely related to the Heteroptera than to the Sternorrhyncha and that the Fulgorodoidea (now Fulgoromorpha) are even more closely related to the Heteroptera than to other groups in the Auchenorrhyncha, thus rendering Homoptera paraphyletic. Gullan (2001) also argued that, based on morphological and molecular studies, the Homoptera were not monophyletic and suggested that the scale insects should be referred to as Hemiptera: Coccoidea or Hemiptera: Sternorrhyncha: Coccoidea.

Although the name Homoptera may now be obsolete (Bourgoin & Campbell 2002), most hemipterists currently accept the suborder Heteroptera. In the Heteroptera, various categories are now used with “morpha” endings. Hence, Stys and Kerzhner (1975), following earlier workers, have proposed these groupings to be infraorders, and thus ranked between suborder and superfamily. These authors suggested that, for consistency, the names should be based on the stem

of the nominal genus with the addition of -morpha. This system has been followed by Schuh (1986), Schuh and Slater (1995) and Weirauch and Schuh (2001), and most other authors working on Hemiptera have accepted the following infraorders within the suborder, all based on nominal genera: Cimidomorpha, Dipsocoromorpha, Enicocephalomorpha, Gerromorpha, Leptopodomorpha, Nepomorpha and Pentatomomorpha.

More recently, based on broad morphological and molecular taxonomic sampling, Cryan and Urban (2012) have provided strong support for the Auchenorrhyncha as a monophyletic group that includes the two higher-level monophyletic groups Fulgoromorpha (containing only Fulgoroidea) and Cicadomorpha (containing three monophyletic groups, Cercopoidea, Cicadoidea and Membracoidea). They also obtained strong support for the monophyly of each of the hemipteran suborders Sternorrhyncha, Coleorrhyncha and Heteroptera. Within the Sternorrhyncha, the infraorders Psyllomorpha, Aleyrodomorpha, Aphidomorpha and Coccoomorpha have been used by Szwedó *et al.* (1990) and Shcherbakov (2007), and Aphidomorpha by Favret *et al.* (2014), but not by most other systematists (e.g. Burckhardt & Ouvrad (2012) with whiteflies). The authors that have accepted these infraorders tend to be those working on families that include fossils (e.g., Aphidomorpha (Heie & Wegierek, 2009)).

To follow the increasing usage of infraorder ranks within the Auchenorrhyncha and Sternorrhyncha, we propose that the infraorder Coccoomorpha be accepted, as this is based on the nominal genus name *Coccus* Linnaeus (which Coccidomorpha would not be). We are suggesting Coccoomorpha rather than the sometimes used Coccinea, because we believe that the only other family-group within the Sternorrhynchan and Auchenorrhyncha in which the -inea ending has sometimes been used is Aphidinea (e.g. Stekolshchikov & Novgorodova, 2013). For those workers who believe there is insufficient evidence for grouping families into superfamilies, the Coccoomorpha would contain only the one superfamily, Coccoidea, within the suborder Sternorrhyncha. However, recent molecular (Gullan & Cook, 2007) and morphological studies (Hodgson & Hardy, 2013) suggest that the present family groupings/superfamilies within the infraorder are likely to change significantly and so Coccoomorpha would be available also for any possible future changes or if the present use of Orthezioidea and Coccoidea by some authors is modified.

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