

ANALYSIS OF LITERATURE ON MALE SCALE INSECTS (COCCOIDEA)

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Abstract:

This paper analyzes existing literature on the morphology and taxonomy of male scale insects, as well as studies related to their biology and evolution. This analysis serves as an important resource for specialists in the field for future research.

Keywords: Scale insects, taxonomy, evolution, literature analysis.

Scale insects (Coccoidea) encompass 56 families, 1233 genera, and 8533 species worldwide [6]. Their males are often winged and have a short lifespan, which significantly distinguishes them from females. Although the morphology, biology, taxonomy, and phylogeny of males are important, research is limited due to their rarity and short lifespan. This analysis reviews existing literature on male scale insects, highlighting their morphological characteristics, taxonomic significance, and evolutionary roles.

Morphological and Taxonomic Analyses. Initial studies on the morphology of male scale insects were conducted by Putnam between 1879 and 1980. He provided brief information about the eyes and antenna segments of males and also noted details regarding their anatomy [19]. Later, Silvestri (1919–1920) studied the number of eyes and the structure of sexual and pre-sexual segments in males of the species *Sphaerolecanium prunastri*, *Eulecanium coryli*, and *Ceroplastes sinensis* [21, 22].

Ghuri examined the morphology of males from 19 genera belonging to the Coccoidea family, specifically focusing on the number and arrangement of their eyes. His findings demonstrated the taxonomic significance of male morphology [7]. Giliomee described the conical head, 10-segmented antennae, elongated forewings, and slender legs of males of the species *Lecaniodiaspis elytrapappi*, emphasizing their importance at the family level [8, 9].

Beinkowsky characterized the dark purple color, white wings, conical head, 10-segmented antennae, and well-developed legs of males of *Lopholeucaspis japonica* [1].

While Kondo, Gullan, and Williams focused on the biology and taxonomy of scale insects, they highlighted the role of male wingedness, small size, and their role in sexual reproduction. They noted that while male morphology is crucial for species identification, detailed information is insufficient [14]. Williams, Ben-Dov, and Matile-Ferrero demonstrated that the morphological characteristics of males play a significant role in species identification in their works on nomenclature and taxonomy [25].

Hodgson and Henderson described males of 31 indigenous species belonging to the Coccidae family in New Zealand, including pupal and prepupal stages, and developed identification keys based on male morphology. This study is one of the important works encompassing males from the geographical region [12]. Kosztarab emphasized the wingedness of males, the reduction of mouthparts, their short lifespan, and specialization for reproduction, as well as the differences in the prepupal and pupal stages compared to other Hemiptera [15]. Miller noted the five-stage development of males, their wingedness, and feeding habits, demonstrating their significance in classification and identification [18].

Evolutionary and Ecological Characteristics. The structure of male scale insect eyes is crucial in evolutionary analyses. Buschbeck and Hauser showed the transition of male Margarodidae from compound eyes to simple eyes. They indicated that simple eyes (ocelli) and elements of compound eyes (ommatidia) in scale insects are associated with highly complex neural networks for processing neurological and visual information [4]. Lambdin highlighted the shape of male wings and the diversity of veins, noting that specialized species exhibit simplification of radial and medial veins, while ancient species retain additional veins [16].

Vea studied the morphology of males from seven species of the Ortheziidae family, including those belonging to the genera *Graminorthezia*, *Insignorthezia*, and *Newsteadia*, using confocal laser scanning microscopy [24]. Giliomee demonstrated that the head and internal skeletal structures (tentorium) of males of *Asterolecanium proteae* are developed in a shape characteristic of the Lecaniinae group, establishing their affiliation with the Coccoidea group and their closeness to Coccidae and Lecaniodiaspididae [8]. Rainato described the morphology and growth stages of males of *Ceroplastes japonicus*, *Ceroplastes rusci*, and *Ceroplastodes dugesii*, developing identification keys for these species [20].

Cytology and Molecular Genetics. Hughes-Schrader emphasized the diversity of sexual determination mechanisms in males and the differences in haploid chromosomes during mitosis and meiosis [13]. Brown showed that in the lecanoid (a special form of sexual chromosome system in scale insects) chromosome model, the haploid chromosome set of males is heterochromatic and is eliminated during spermatogenesis [2]. Brown and DeLotto

discussed that in males of *Aspidiotus simulans*, part of the chromosomes disappears during the embryonic stage, leaving four chromosomes [3].

Unruh and Gullan showed that the molecular data of male *Iceryini* correspond to geographical distribution, identifying *Gueriniella* as a separate evolutionary lineage [23]. Gullan and Cook highlighted the importance of male genitalia, abdominal segments, and wing shape in identification at the family and species levels, revisiting their phylogenetic relationships [10]. Hodgson conducted a phylogenetic analysis based on the winged morphology of males from 94 species and 16 families, determining the closeness of the *Stictococcidae*, *Beesoniidae*, *Conchaspidae*, and *Diaspididae* families [11].

Fossil and Ecological Studies. Vea and Grimaldi conducted a phylogenetic study based on the morphological analysis of male scale insects preserved in amber from ancient trees during the Cretaceous (approximately 145–66 million years ago) and Eocene (approximately 56–34 million years ago) periods. This study showed that morphological characteristics have remained relatively unchanged over long geological periods [24]. Foldi investigated the physiological and microclimate protection of *Archaeococcoid* males in tropical high mountains, demonstrating the evolutionary significance of ecological adaptation [5]. Mansour et al. emphasized the short lifespan and mating role of males of *Planococcus ficus*, *Planococcus citri*, *Saissetia oleae*, and *Parlatoria ziziphi* in the Mediterranean region, noting that their biology and natural enemies are poorly studied [17].

The morphology and genetics of male scale insects (Coccoidea) play a crucial role in understanding taxonomy and evolution. Males are often winged and have a short lifespan, making their study limited. The lecanoid chromosome model confirmed by Brown unveiled unique mechanisms in the genetics of scale insects. Additionally, the morphology of eyes, antennae, and wings of males is significant in taxonomic classification. However, their rarity and short lifespan have constrained information about them. Therefore, it is necessary to expand research on the morphology, evolution, and genetics of male scale insects.

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