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COMPARATIVE MORPHOLOGY OF THE ANAL TUBERCLE AND ASSOCIATED STRUCTURES OF SOME LAC INSECTS (HEMIPTERA: COCCOIDEA: KERRIIDAE).

ABSTRACT

COMPARATIVE MORPHOLOGY OF THE ANAL TUBERCLE AND ASSOCIATED STRUCTURES OF SOME LAC INSECTS (HEMIPTERA: COCCOIDEA: KERRIIDAE).

Specimens of *Austrotachardia acaciae* (Maskell), *Austrotachardia* sp. ex *Cassinia* spp., *Kerria lacca* (Kerr) and *Paratachardina decorella* (Maskell) were examined under the scanning electron microscope (SEM). SEM images were compared with observations under the light microscope. The anal tubercles and associated structures of each species are described and compared. The presence of what appears to be vestiges of an anal cleft in *Paratachardina* is interpreted as suggesting the possible evolution of the lac insects from a lecanoid ancestor that possessed an anal cleft. The results provide an easier interpretation of these characters under the light microscope.

Key words: morphology, pre-anal plate, supra-anal plate, tubular plate, anal fringe, anal ring, anal collar, anal ring wax-pores, anal tube, perisetal micropores, homology, Coccidae, Pseudococcidae, *Acacia*, *Callitris*, Australia, Thailand.

INTRODUCTION

Among the scale insects (Coccoidea), the lac insects (Kerriidae) possess very unusual morphological details. The family is probably the easiest to define as a group as it has, in addition to the anal tubercle, such unique characteristics as the dorsal spine, brachia and brachial plates, among others. Ferris (as quoted by Chamberlin, 1923) wrote that they "constitute a very peculiar and isolated group" and their unique characters "are apparently not homologous with anything found in any other" Coccoidea.

However, with the exception of the Indian lac insect (*Kerria lacca* (Kerr)), the group is one of the (if not *the*) least studied coccoid families, despite the works of Chamberlin (1923, 1925) and Varshney (1977, 1984). This neglect is probably due to the difficulty of preparing slide mounts and their relative rarity as compared to other scale insects. Furthermore, taxonomically important characters are difficult to interpret under the light microscope

because, although these odd insects are generally membranous and soft-bodied, the significant characters are usually highly sclerotised.

This paper deals with the comparative morphology of the anal tubercle and associated structures of four species of lac insects. It is the first of a series of studies on the morphological characters of the Kerriidae. By studying the external appearance of lac insects under the scanning electron microscope (SEM), especially the highly sclerotised structures, this paper aims to: (1) provide a better understanding of their morphology; (2) facilitate the interpretation of characters under the light microscope, and (3) gain insights into the possible putative relationships of the Kerriidae with other groups of scale insects.

In this study, standard procedures were followed in preparing specimens for slide mounts and for SEM. For the latter, all specimens were taken from alcohol-preserved collections except for *K. lacca* which were from a dried lac stick. Slide mounts of the specimens examined are deposited in the Australian National Insect Collection (ANIC), CSIRO Entomology, Canberra, Australia, with the exception that the specimens of *K. lacca* are deposited in the Entomology Section of the UPLB Museum of Natural History.

RESULTS AND DISCUSSION

General morphology of the anal tubercle

Basically, the anal tubercle is the more or less heavily sclerotised posterior prolongation of the body. In the three genera we have so far studied, this structure is held upright on the dorso-posterior area and this is probably also true for the rest of the Kerriidae. In general, the anal tubercle is composed of plates or sclerotised regions referred to as the supra-anal plate, the anal fringe and the adjacent and/or intermittent membranous areas. In some species or groups, a pre-anal plate precedes the supra-anal plate, as in two known *Austrotachardia* species. The distal end of the tubercle of all lac insects bears the anal ring with its complement of ducts, pores and anal-ring setae and often an anal tube. All Kerriidae possess 10 anal-ring setae.

The supra-anal plate is an incomplete tubular plate that covers the anal tubercle. In some groups, e.g., *Metatachardia*, a pre-anal plate is located below it or on the area of the anal tubercle, next to the body. This plate (together with the pre-anal plate when present) comprises the principal sclerotised area of the anal tubercle. In our opinion, however, the pre-anal plate represents a segment anterior to the anal ring (e.g., possibly abdominal

segment VII) that, together with the anal and penultimate segments, forms the anal tubercle, at least for *Austrotachardia* species. As such, the pre-anal plate is never really "absent" but is either in a membranous or a sclerotised state. Further studies of other lac insects will probably reveal intermediate states such as slightly sclerotised and highly sclerotised.

Both Chamberlin (1923) and Varshney (1977) described the anal fringe as some sort of apron possessing a median cleft and several irregular lobes that project posteriorly. In live specimens and under SEM, the boundaries and details of the sclerotised plates (pre-anal and supra-anal plates), as well as the anal fringe, are not easily discernible. Under SEM, however, these regions are bounded by areas of depression or varying degrees of wrinkling or folding, the latter indicating its membranous nature and thus indicating that it is likely to be affected by drying and/or fixing. Under the light microscope, the boundaries of these plates are better seen when slides have been prepared so that the anal tubercle is expanded or extended.

Brief descriptions of anal tubercles:

Austrotachardia acaciae (Maskell) (Fig. 1)

Anal tubercle large and elongate, broadly dome-shaped, with vulva at base of posterior side; supra-anal plate strongly sclerotised, with fine sculpturing (i.e. micropapillose) distally; pre-anal plate absent or probably membranous and not evident; anal fringe apparently entire, without an obvious median cleft or line of filaments, somewhat broadly spatulate on longer (medial) end and bearing 1-2 marginal setae on each apex; anal ring 4-sectored, surrounded by a circular structure here referred to as the collar; anterior anal-ring sectors each with 3 anal-ring setae, posterior each with 2 setae; anal-ring setae longer than anal fringe; anal tube cylindrical, very prominent.

Material examined. SEM & slide mounts: AUSTRALIA: Northern Territory (NT): Alice Springs, 23°43'S, 133°53'E, ex stem of *Acacia aneura* (mulga) (Leguminosae), P.J. Gullan coll., 01.VI.1992. NT: N'Dhala Gorge, 23°29'S, 134°27'38"E, ex stem of *A. aneura* group, P.J. Gullan coll., 25.V.1992. Other slide mounts: South Australia: 75km N of Coober Pedy, ex *Acacia* sp., F.D.M. coll., 28.VIII.1976. NT: Haast's Bluff Reserve, ex *Acacia aneura*, J.B. Cleland coll., VIII.1957.

Remarks. Chamberlin (1923) did not have sufficient material "to permit working out the anal fringe" of this species. He also remarked that "the anal tubercle of this species requires more careful study to determine whether or

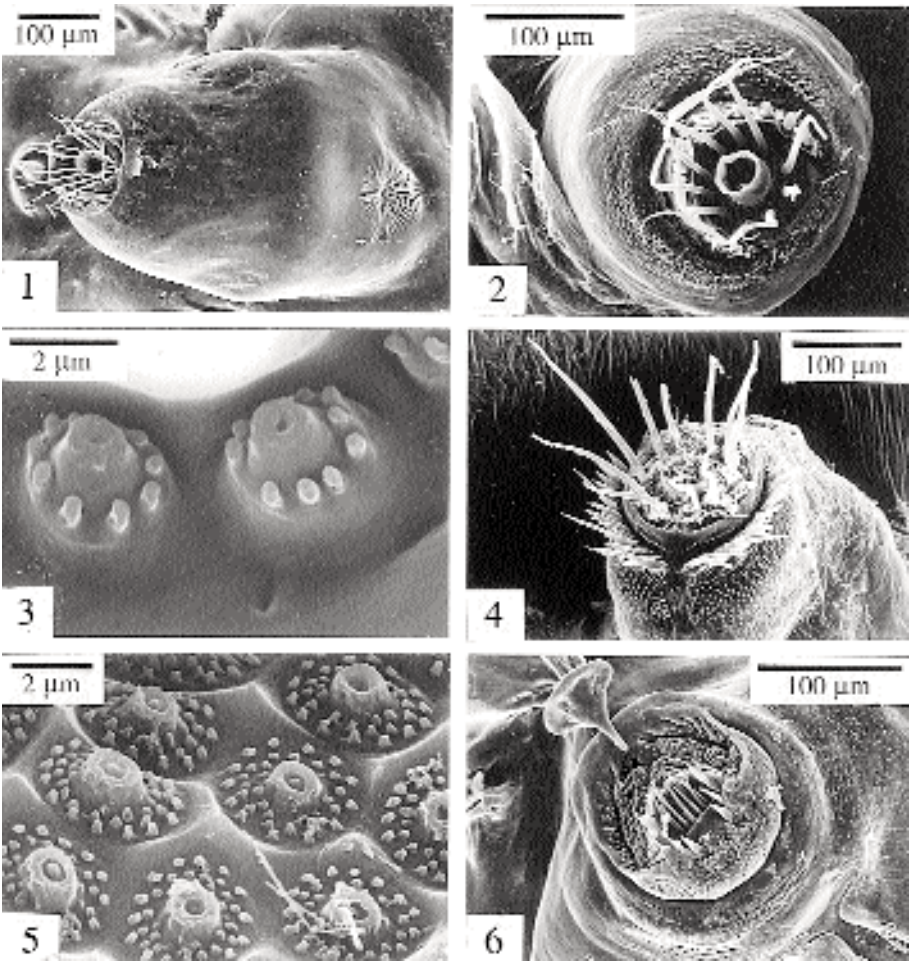
not there is a truly essential difference between it and the type found in other species of the genus." We now believe that the anal fringe of this species is entire and that the pair of ligulate lobes known in other *Austrotachardia* species is absent. This is probably a case of secondary fusion of the lobes, since some slide-mounted specimens reveal a faint membranous line in the medial area of the anal fringe. Thus, the anal fringe may not be typical of the genus *Austrotachardia*. Chamberlin (1923) described the anal ring as being "retracted far under a heavy chitinous projection entirely different in character from the typical fringe", and this projection is here interpreted to be the anal collar (as shown by our SEM observations), which has not previously been recorded.

Austrotachardia sp. ex ***Cassinia*** (Figs 2, 3)

Anal tubercle large, elongate and broadly dome-shaped but relatively smaller than that of *A. acaciae*; supra-anal plate strongly sclerotised and tuberculate around tip; pre-anal plate present as thin subcircular or subcylindrical patch below much larger supra-anal plate; anal fringe consisting of fairly broadly ligulate lobes on either side of a median cleft, each lobe bearing 5-6 fimbriate, bluntly spinose or digitate setae on the margins and 1-2 shorter but conical setae approximately apically; anal ring 4-sectored, each anterior sector embracing 3 anal-ring setae, each posterior sector with 2 setae; anal-ring setae at least 3 times as long as anal fringe, each surrounded by about eight perisetal micropores (Fig. 3) and each micropore surrounded by 10-12 or more minute tubercles; anal collar narrow; anal tube prominent but not as obvious as that of *A. acaciae*.

Material examined. SEM: AUSTRALIA: New South Wales (NSW): Orange, from culture on *Cassinia* (Compositae), M.H. Campbell coll., 08.II.1995. Slide mounts: same locality but from property of P. Wykes, Kerr's Creek, ex *Cassinia arcuata,* M.H. Campbell coll., -.XII.1990.

Remarks. This possibly undescribed species appears to be morphologically close to *A. melaleucae* in possessing a thin pre-anal plate and in a few other characters. The differences between the two species will be covered in a future revision of the genus. Based on our observations under SEM and the light microscope, as well as the descriptions provided by Chamberlin (1923), the anal fringe of this species may be said to be typical (as defined by Chamberlin) of *Austrotachardia*. The existence of minute structures surrounding each anal-ring seta is hitherto unknown in any lac insect species. They are possibly also secretory in function and might also be present in other *Austrotachardia* species at least, although we have so far been unable to observe them on *A. acaciae*.



Figures 1-6. SEM images of anal tubercles and associated structures of some lac insects (Kerriidae): **1.** *Austrotachardia acaciae*, posterior view showing vulva at the base; **2-3.** *Austrotachardia* sp. ex *Cassinia*: 2. Dorsal view; 3. Details of perisetal micropores; **4-5.** *Kerria lacca*: 4. Posterodorsal aspect; 5. Details of perisetal micropores; **6.** *Paratachardina decorella*, dorsal view, showing flap-like structures

Kerria lacca (Kerr) (Figs 4, 5)

Anal tubercle large, elongate (longer than widest width) but relatively narrower or thinner than that of *A. acaciae,* except for the setae and fringe, conical but almost truncate at tip; supra-anal plate strongly sclerotised and papillose; no pre-anal plate visible; anal fringe sharply acute, consisting of fairly short but wide lobes on either side of a median cleft, each lobe bearing about 3 ligulate setae, as well as variously digitate or fimbriate fringes on margins and with 1-2 small conical setae at apex; anal ring 4-sectored, bordered by a fairly narrow collar; sectoral divisions not as well defined as those of *Austrotachardia*; anal-ring setae longer than anal fringe; perisetal micropores scattered around each sector, more numerous than those of *Austrotachardia*; each micropore surrounded by at least 40 minute tubercles (Fig. 5); anal tube prominent but only about 1/6 as long as anal-ring setae.

Material examined. SEM: THAILAND: Bangkok?, in cultivation, no host data, F.M. Laigo coll., 02.X.1960.

Remarks. Kerria lacca is the most well-known and most frequently described lac insect. Even so, the anal collar that borders the anal ring and the micropores surrounding the anal-ring setae have not previously been described. These micropores probably correspond to the anal-ring wax-pores observed under the light microscope in other coccoid families, e.g., in the Pseudococcidae. In *K. lacca*, the anal fringe also possesses fringes in the form of long, variously digitate or fimbriate extensions of the major lobes, in addition to the definable setae.

Paratachardina decorella (Maskell) (Fig. 6)

Anal tubercle short, broader than long, not as prominent as in other genera; lateral profile quite convex; supra-anal plate strongly sclerotised, top portion tuberculate, apparently eversible/depressible, with posterior portion papillose; pre-anal plate visible in slide-mounted specimens as a very thin slightly sclerotised semicircular bar that runs around base of supra-anal plate and fades or blends with surrounding membranous area; anal fringe consisting of a pair of angular, fairly long, ligulate lobes on either side of a median cleft; lobes of anal fringe bearing 1-2 marginal setae and 1-2 smaller conical setae at posterior apex; anal ring entire, not sectored; anal-ring setae longer than anal fringe; anal tube not obvious. With a pair of flap-like structures present on posterior side at the base of anal tubercle, these not obvious under light microscope.

Material examined. SEM and slide mounts: AUSTRALIA: NT: Watarrka National Park, Stokes Creek, 24°21'S, 131°45'E, ex stem of *Callitris*

columellaris (Cupressaceae), P.J. Gullan, coll., 04.VI.1992. Slide mounts: NSW: 20km E of Temora, 1km E of Springdale, ex *Callitris glaucophylla*, P.J. Gullan coll., 30.X.1993.

Remarks. The pair of flap-like structures on the posterior side of the anal tubercle are most probably the terminal ends of the pre-anal or supra-anal plate that have not fused fully with the rest of the tubercle integument. From many angles, these flaps appear to be vestiges of an anal cleft.

COMPARATIVE NOTES AND HYPOTHESES:

The presence of what appears to be vestiges of an anal cleft in *Paratachardina* suggests that the lac insect group may have evolved from an ancestor that bears such a structure. At the same time, the pair of flap-like structures on the posterior side of the anal tubercle suggests that the supra-anal plate is homologous to the anal cleft of coccids and related cleft-bearing families. In addition, the structure of the anal fringe, especially its possession of a median cleft and its position in the anal tubercle (i.e. just above or anterior to the anal ring) suggests an homology with the anal plates of the Coccidae. In *A. acaciae*, however, there seems to have been some secondary fusion of the lobes of the anal fringe. Furthermore, the presence of an anal tube (which is very prominent in *A. acaciae*) suggests and confirms an earlier hypothesis that lac insects belong to the lecanoid family-group. Thus, the whole morphological structure of the anal tubercle, as complex as it is in the adult female Kerriidae and probably involving fusion and sclerotisation, appears to represent a highly derived character that is homologous to the anal structures of coccids – e.g., the anal cleft, anal plates, anal tube, anal ring and its complement of setae and wax pores. Indeed, the Kerriidae (as the Tachardiidae) was the sister group to the Coccidae in one of Miller & Hodgson's (1997 - Fig. 1.1.3.7.5) cladograms.

These hypotheses may be supported in the future by further evidence from an on-going study of first-instar nymphs of some *Austrotachardia* species. Hodgson's (1995) study of plate-like structures associated with anal areas of lecanoid Coccoidea did not discuss the ontogeny of these structures in Kerriidae and 2 other families, due to lack of information on first-instar nymphs. However, an earlier work by Miller (1991) included an illustration of a first-instar lac insect and so did Chamberlin (1923). There are some differences between our interpretation and that of Miller (1991) and Chamberlin (1923) with regard to the structure they labelled as the "supra-anal plate". We do not intend to discuss this matter in detail here but we tentatively propose that Miller's and Chamberlin's "supra-anal plate" on first-instar nymphs might actually be the precursor of the anal fringe.

The difficulty of interpreting highly sclerotised characters under the light microscope has not only been experienced by the present authors but also reported by other students of Coccoidea, such as Chamberlin (1923). SEM studies have not only helped to interpret these characters under the light microscope but have also revealed previously unknown details of kerriid morphology, such as the anal collar, the perisetal micropores and their accompanying minute tubercles, and the actual configuration of the anal fringe of *A. acaciae*. Further SEM studies, covering other difficult groups or species, will probably bring out more interesting data that will improve our understanding of the relationships and classification of the Kerriidae.

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