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Morphology of several types of cuticular suckers on mites

(Arachnida, Acarina)

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Abstract

The anal sucker of eriophyids acts as an adhesive device that is used in feeding, moulting and dispersal. Besides the suction capabilities of the anal sucker, a fluid substance is secreted just before the moulting process which hardens and anchors the mite to the substrate. There are three muscles that are associated with the anal sucker. These muscles and haemocoelic pressure provide the necessary mechanism for contraction and extension of the anal sucker. The reduction of the epicuticle and exocuticle along with the expansion of the endocuticle allows for flexibility of the anal sucker. The acarid sucker plate consists of three pairs of suckers, three apodemes and two pairs of conoidal setae. The anterior and medial suckers are modified setae whereas the lateral sucker is formed from the sucker plate cuticle. From an external view, the lateral apodemes are circular and the posterior apodeme is pear shape but internally the laterals are elliptical and the posterior is bilobed with a long extension. The sucker plate attaches the mite to a host and is carried to a new environment. The posterior suckers of heterozerconids are modified portions of the cuticle. Each sucker is surrounded by a wide ridge and the sucker has a thick basal collar and a pleated apical portion. There are several rows of denticles on the collar and the apex of the sucker. The suckers are used for attachment to the host while the mite feeds and for dispersal.

Introduction

Throughout the Phylum Arthropoda there are many different forms of adhesive organs. These suction devices occur frequently in the three major classes, Crustacea, Insecta, and Arachnida. Adhesive organs may be modified setae, mouthparts or cuticular areas of the body wall. They are used in various ways depending upon the environment in which the animal lives, and its feeding, disperal and mating behaviours.

Suction devices are present in three suborders of Acarina. Members of the families Heterozerconidae and Discozerconidae (Mesostigmata), which are associated with millipedes and centipedes, have suckers for attachment to their hosts (Krantz 1978). Many species representing various families of Astigmata possess suckers that perform a wide variety of functions such as the paranal suckers and sucker-like setae on tarsus IV of many astigmatid male mites are used in copulation (O'Conner 1982; Baker & Krantz 1985). The modified deutonymph, which is a phoretic stage, may have a sucker plate that is used to attach to a host carrier. Members of the Eriophyidae (Prostigmata) possess an anal sucker that has several functions such as dispersal. Whitmoyer et al. (1972) and Nuzzaci (1976) provide brief descriptions of the eriophyid anal sucker. This paper presents a description of the cuticular suckers of *Aceria mississippiensis* Chandrapatya & Baker and *Coptophylla caroliniani* Chandrapatya & Baker (Eriophyidae), *Sancassania mycophagus* (Megnin) (Acaridae) and *Heterozercon* spec. (Heterozerconidae).

Materials and methods

Specimens for scanning electron microscopy were either fixed in 3 % glutaraldehyde and 3 % paraformaldehyde in cacodylate buffer for 8 h at room temperature or taken from ethanol. The mites were washed in distilled water for 30 minutes and then post-fixed in 4 % OsO_4 for 24 h. After the post-fixation the specimens were washed for 30 minutes in distilled water and dehydrated in a graded series of ethanol to absolute before either critical point drying (CPD) or freeze fracturing followed by CPD. The mites were mounted on stubs with double-sided sticky tape and coated with Au/Pd. They were examined with Hitachi HHS-2R SEM at 20 kV.

Specimens for transmission electron microscopy were placed in a fixative containing 2.5 % glutaraldehye, 2.5 % paraformadehyde and 2.0 % acrolein in cacodylate buffer for 8 h. at room temperature. The specimens were washed in buffer for 30 minutes, then post-fixed in 2 % OsO_4 in cacodylate buffer for 5 h. at 4° C. After washing and dehydrating the specimens, they were infiltrated with Spurr's low viscosity embedding medium for 3 days in order to overcome penetration problems caused by the cuticle. Sections were cut with glass knives and thick sections were placed on glass slides and stained with toluidine blue. Thin sections were placed on formvar-coated grids and stained for 20 minutes in saturated uranyl acetate in distilled water and with lead citrate for 4 minutes. Sections were examined with Siemens Elmiskop 101 transmission electron microscope at 80 kV.

Results and discussion

The anal sucker of eriophyids occurs on all post-embryonic stages and when it is extended, the sukker is about 10 μm long in the adults. It forms an inverted U-shaped area around the anal opening (Fig. 1). The sucker is pleated and wrinkled in its retracted state which indicates the cuticle is flexible. When the anal sucker is extended due to haemocoelic pressure, the cuticular surface is smooth and does not exhibit any of the ridges or microtubercles that are found on the dorsal and ventral surfaces of the opisthosoma. Before the moulting process begins, the anal sucker is extended and attached to the plant surface, then a viscous substance is secreted from the anal opening which firmly secures the mite to the surface (Figs. 2, 3). After the new cuticle is formed, the old cuticle splits along the anterior dorsal shield and the next stage emerges from the attached exuviae (Figs. 4, 5).

The feeding behaviour of eriophyid mites involves the use of the anal sucker. Before *A. mississippiensis* and *C. caroliniani* begin to feed on plant tissue, the anal sucker anchors the mite to the plant surface. Then the chelicerae puncture the plant cell wall and the cell contents are taken into the digestive system. This feeding procedure is similar to what has been described for *Diptacus bederiphagus* Nuzzaci (Nuzzaci 1976) and *Aculus comatus* (Nalepa) (Krantz 1973).

The anal sucker is used in the disperal of eriophyid mites. These mites are known to attach to many insects; aphids, coccinellids, bees, green bugs, leaf hoppers, and lepidopterous larvae (Warburton & Embleton 1902; Massee 1928; Slykhius 1955; Gibson & Painter 1957). The wind is also involved in the disperal of eriophyid mites. The anal sucker is used to erect the body of the mite so that it is perpendicular to the leaf surface or the mites can create chains in which mites are attached to one another by the anal sucker (Gibson & Painter 1957; Nault & Styer 1969). This type of position allows the mite to be more exposed to any air currents that may pass over the leaf surface. Eriophyids are also capable of leaping, and the anal sucker plays an important role in this behavior (Warburton & Embleton 1902; Nalepa 1910; Massee 1928).

The anal sucker is extended by haemocoelic pressure and is contracted by three muscles. These muscles originate on the dorsal and dorso-lateral areas of the posterior opisthosoma and insert on the distal end of the anal sucker (Fig. 6). The two dorso-lateral muscles are shorter than the dorsal muscle. This muscular arrangement is similar to other eriophyid mites (Shevchenko 1970). Desmosome-like structures connect the muscles to the cuticle which resemble muscle connections in other mites (Fig. 6) (Kuo et al. 1971; Beadle 1973).

The cuticle of the anal sucker differs considerably from the cuticle that is found in other body regions. The endocuticle makes up most of the thickness of the cuticle in this region (Fig. 6). Since the

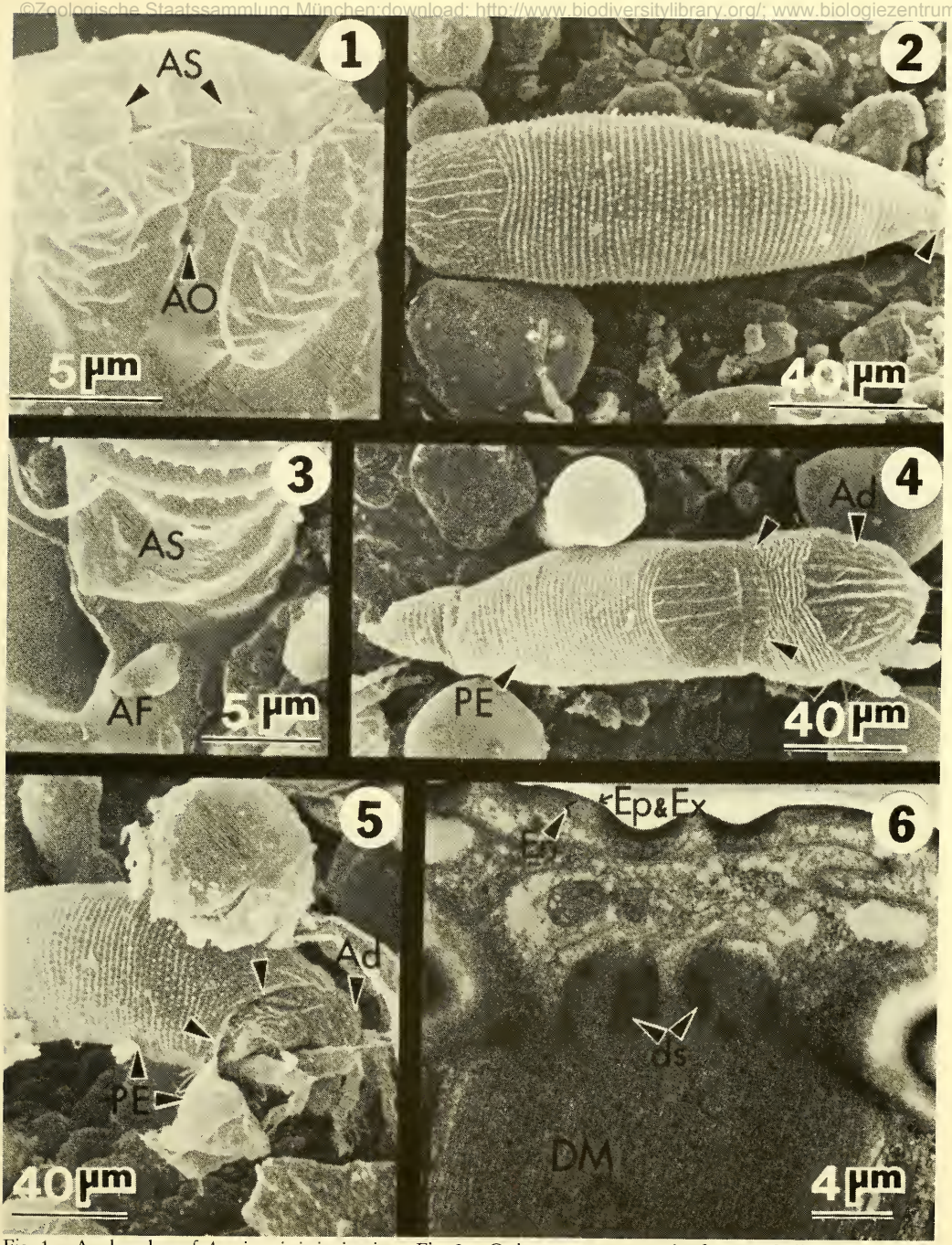

Fig. 1. Anal sucker of *Aceria mississippiensis*. – Fig. 2. Quiescent protonymph of *Coptophylla caroliniani* attached to the leaf surface (arrow = point of attachment.). – Fig. 3. Higher magnification of Fig. 2. – Fig. 4. Dorsal view of the emerging *Coptophylla caroliniani* adult from the protonymphal exuviae (arrows = ecdysial cleavage line on dorsal shield). – Fig. 5. Lateral view of Fig. 4. – Fig. 6. Section of the anal sucker of *Aceria mississippiensis* showing the dorsal muscle and expanded endocuticle.

AF = adhesive fluid; AO = anal opening; AS = anal sucker; D = dorsal shield; DM = dorsal muscle; DS = desmosome-like structure; EN = endocuticle; EP = epicuticle; EX = exocuticle.

epicuticle and exocuticle layers are almost lacking and the endocuticle is not tanned, these two characteristics would provide the necessary flexibility to the cuticle of the anal sucker. The cuticle of the pygypodia of photurid firefly larvae is quite similar to the anal sucker cuticle (Domagala & Ghiradella 1984). Both structures are employed as adhesive organs.

The deutonymphal sucker plate of *Sancassania mycophagus* is ovate (72 μm wide and 66 μm long) and is situated on the venter between legs IV and the posterior end of the body (Fig. 7). The anal area lies between the two anterior suckers (Fig. 7). There are two pairs of conoidal setae, one pair is posterior of the large medial suckers and the other is laterad of these suckers (Figs. 7, 8). The conoids are spherical and the surface consists of concentric ridges (Figs. 7, 8). There are 3 apodemes (2 lateral, 1 posterior) that are posterior to the medial suckers and between the 2 pairs of conoidal setae (Figs. 7, 8). The apodemes have a smooth outer surface and the edge is slightly ridged (Figs. 7, 8). The outline of the lateral apodemes is circular whereas the posterior one is pear-shaped (Figs. 7, 8). The internal cuticular portion of the lateral apodemes is elliptical (Figs. 9, 11) and the posterior apodeme has a long anterior extension and a bilobed posterior (Fig. 9).

There are 3 pairs of suckers that have the following characteristics; 1. striated-ridged borders, 2. strongly convex and, 3. the edge is raised and not attached to the rest of the sucker plate (Figs. 7, 8). The anterior suckers are situated on either side of the reduced anal opening and are 16.5 μm in diameter. This pair of suckers is circular and in the centre of each sucker there is a small nipple-like projection which is a setal remnant (Fig. 8). The medial suckers which are the largest (32 μm wide and 38 μm long) have two setal remnants in the centre (Fig. 8). The third pair (lateral suckers) which lie laterally

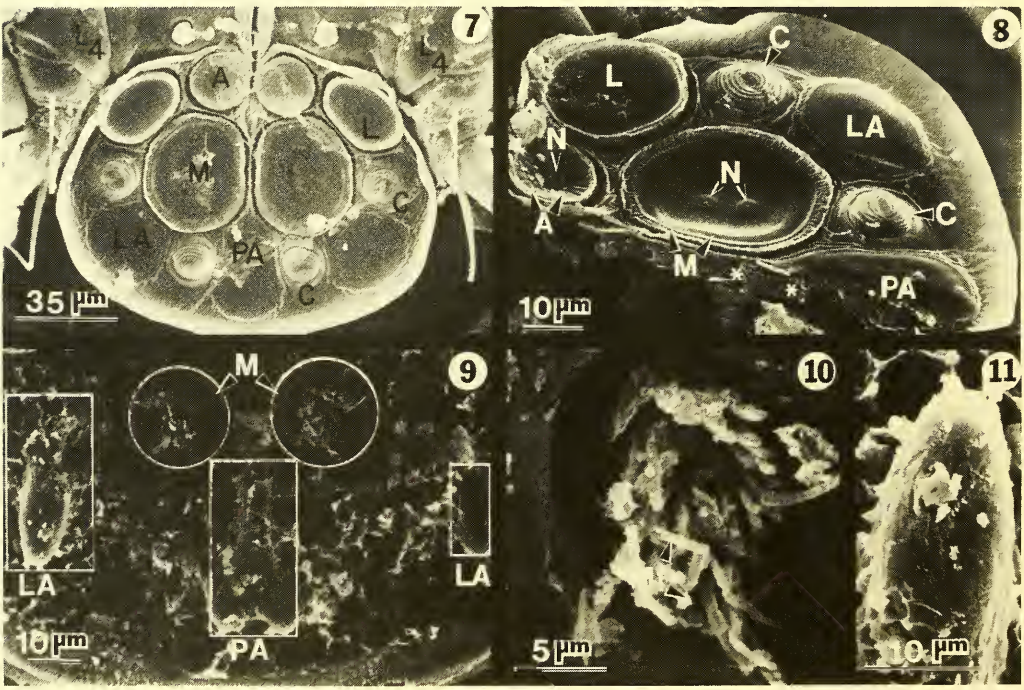

Fig. 7. *Sancassania mycophagus*, sucker plate. – Fig. 8. Fractured sucker plate (Note the thick cuticle ** and the raised suckers). – Fig. 9. Internal view of the apodemes. – Fig. 10. Muscle fibers associated with the medial sukker. – Fig. 11. Internal view of lateral apodeme.

A = anterior sucker; C = conoidal seta; L = lateral sucker; L_4 = leg 4; LA = lateral apodeme; M = medial sucker; MF = muscle fibers; N = nipplelike projection; PA = posterior apodeme.

to the anterior and medial suckers are 17 μm wide and 23 μm long (Figs. 7, 8). There is a large bundle of muscle fibres that is attached internally to the base of the sucker (Figs. 9, 10) and a cuticular rim surrounds the opening from which the muscle bundles arise (Figs. 9, 10).

Woodring & Carter (1974) described the components of the sucker plate of *Sancassania boharti* (Cross) which is different from *S. mycophagus* in several aspects. They do not mention the cuticular sculpturing that occurs on the surface of the conoidal setae and there is a description of an "O" in the anterior sucker and the "8" in the medial sucker which probably corresponds the nipple-like setal remnants in the same suckers of *S. mycophagus*. The anterior sucker plate apodemes of *S. boharti* correspond to the lateral suckers of *S. mycophagus* which do not resemble the lateral or posterior apodemes. The aforementioned external characteristics and from the ultrastructural information by Kuo (1972) indicate that these structures are suckers. From the short description of *Sancassania phyllognathi* (Samsinak) by Samsinak et al. (1974), the sucker plate resembles that of *S. mycophagus*. The deutonymph is phoretic and uses the sucker plate to attach to a wide variety of invertebrate carriers (Krantz 1978).

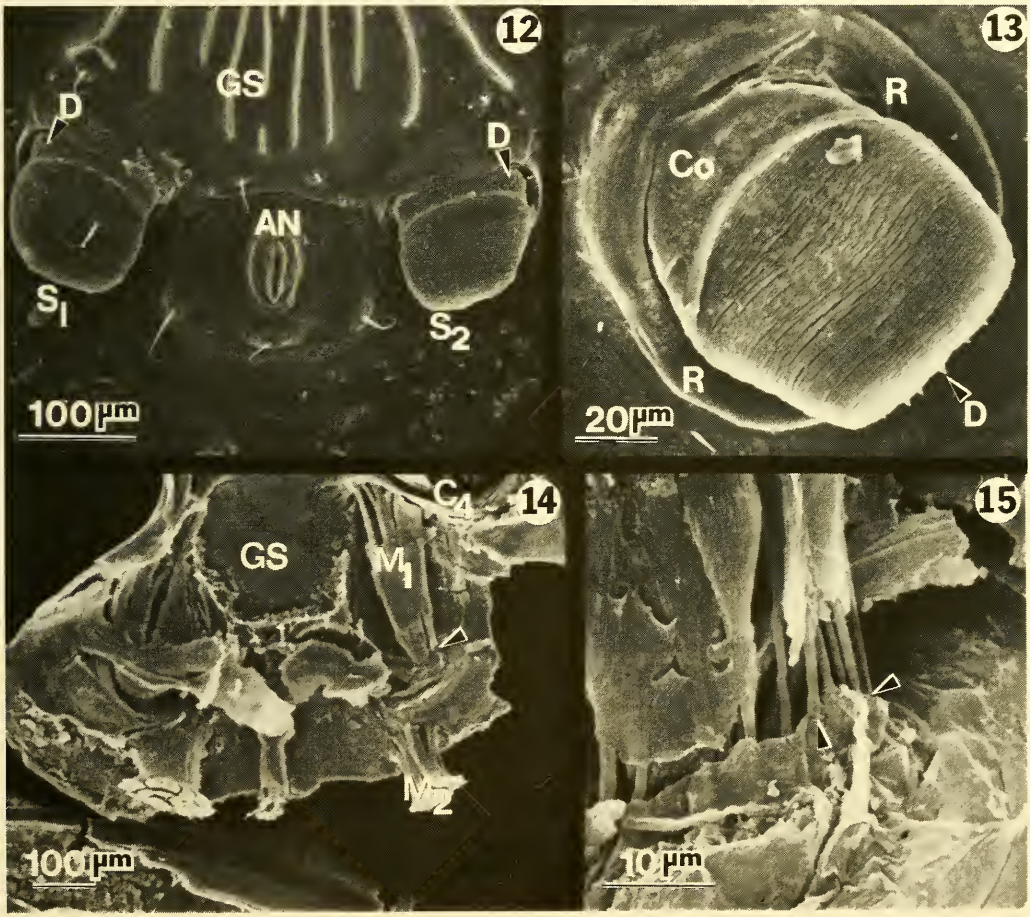

Fig. 12. Posterior region of the venter. – Fig. 13. Heterozerconid sucker. – Fig. 14. Fractured mite showing the internal area of the posterior venter. – Fig. 15. Muscle fibers attached to cuticle of the sucker.

AN = anus; C_4 = coxa 4; Co = collar; D = denticles; GS = genital shield; M_1, M_2 = sucker muscles; R = sucker ridge; S_1, S_2 = suckers; arrows = muscle attachment sites.

The suckers on the females and males of heterozerconids resemble two fleshy pouches that are situated laterad of the anal opening and just below the genital shield (Figs. 12, 13). Each sucker has a basal collar which is composed of thick cuticle with denticles whereas the apical three-fourths is composed of flexible and pleated cuticle with a row of stout, triangular spines (Figs. 12, 13). A wide ridge of cuticle surrounds each sucker (Fig. 13). There are two groups of muscle bundles that are associated with each sucker (Fig. 14). The first muscle bundle (M_1) is attached to the basal region of coxa IV and the genital shield and is inserted on the inner portion of the cuticular ridge that surrounds the sucker (Fig. 14). The second muscle bundle (M_2) is attached to the dorsum of the mite and is inserted on the opposite side of the cuticular ridge from M_1 (Fig. 14). Many muscle strands from each muscle bundle are attached to the cuticle (Fig. 15) by modified epidermal cells and desmosome-like structures which is unique as compared to other arthropods (Kuo et al. 1971; Beadle 1973).

These suckers are probably cuticular modifications as the anal sucker of the eriophyid or the anal suckers of the male *Rhizoglyphus robini* Claparede (Baker & Krantz 1985). Heterozerconids are mostly parasitic mites that live on millipedes (Krantz 1978) and they use these suckers to attach to their host.

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