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RICHARD A. BAKER *

'PLASTRONS AND ADHESIVE ORGANS' – THE FUNCTIONAL MORPHOLOGY OF SURFACE STRUCTURES IN THE BROAD MITE, *POLYPHAGOTARSONEMUS LATUS* (BANKS, 1904)

Abstract

Consideration is given to the structure and function of the adhesive organ in the male and of the protuberances on the surface of the egg in the Broad mite, *Polyphagotarsonemus latus*. Scanning Electron microscopy is used to reveal these structures. The adhesive organ serves as a sucker in order that males can carry pharate females. It is believed that the protuberances are part of a discontinuous plastron for gaseous exchange.

Keywords: S.E.M., mite, egg, plastron, male, adhesive organ

Introduction

The Broad Mite is the most important tarsonemid mite found in greenhouses (Zhang, 2003), feeding on a range of host plant species. Zhang (2003) summarizes the knowledge of distribution, host plants, damage symptoms, life history, general biology, control and management. This mite can be a serious pest of commercial crops and ornamental plants, especially those grown in greenhouses. A complete list of the food crops and other details about this mite are given by

* Faculty of Biological Sciences, University of Leeds, Leeds LS2 9JT, UK. pabrab@leeds.ac.uk.

Fasulo (see website). The mite has a wide geographical range and has been recorded attacking plants in the tropics as well as in temperate regions and. heavy infestations can occur on buds, flowers and small developing fruits and large populations can build up before being detected. Symptoms of infestation include stunted and twisted leaves, distorted shoots (which go brown and appear shrivelled and burnt) and cracked fruit. Cross and Bassett (1982) describe the symptoms in detail. In Poland, Labanowski and Soika (2006) and Labanowski (2008) have identified the Broad mite in a list of new pests on ornamental plants in Polish commercial glasshouses, the result they believe of international trade with EU countries. Miticides are used for the control of this species.

Under optimal conditions (ca 25°C and high RH) the life-cycle takes about a week to complete (Gerson 1992). Eggs hatch after 2 days. The larva feeds for a day and, after feeding, undergoes an immobile quiescent stage. Pharate females remain in the larval skin and are carried by the males. According to Flechtmann and Flechtmann (1984) non-fertilized females lay 3 to 18 eggs (mean 7.8) and produce only male offspring, with n = 2 chromosomes. Fertilized eggs produce diploid females which can lay around 40 eggs (Gerson 1992).

Several authors have observed 'protuberances' on the upper surface of the egg which can vary up to around 30 in number and are evenly distributed in rows, but confusingly have used different words to describe them. Fasulo (see website) described them as "scattered white tufts", Callaini and Mazzini (1984) as "raised irregular mounds", Montasser et al. (2011) refer to them as "sacs", Martin (1991) as "tubercles" and Witaliñski (1993) as locular chambers. Some of these different descriptions may in part be due to the effects produced by the techniques used during SEM preparation but they are clear and distinct structures. Witaliński (1993) believes that this exo-chorion material is deposited on the egg surface as the egg passes through the distal part of the oviduct. Montasser et al (2011), working on *P. latus*, also noted "peripheral tubercles "at the bases of these sacs and a "roughly perforated area in each sac".

The fine structure of the egg shell has been described in the mites *Tyrophagus putrescentiae* (Callaini and Mazzini 1984) and *Sarcoptes scabiei* (Mazzini and Baiocchi 1983). Martin (1991) used Scanning Electron Microscopy to examine the life cycle stages of *P. latus*, including the egg.

Materials and Methods

Mite eggs and life cycle stages were obtained from *Capsicum annuum* L. one of the pepper plant species maintained in the greenhouse facilities at the University of Leeds, Yorkshire, UK. Routine Scanning Electron Microscope methods were used. Eggs and other life cycle stages were attached, without prior treatment, to double sided sellotape on stubs, gold coated and examined in a Camscan electron microscope.

Results and Discussion

Males actively seeks out immobile pharate females and, once located, can carry them (Fig. 1) for up to 24 hours, using the large and obvious sucker-like organ (Fig. 2). This structure is situated on the posterior dorsal surface of the male. It is roughly 20µm across and, on its ventral side, is surrounded by spine-like projections from the cuticular surface. There is a hollow in the centre of the sucker (Fig. 2) and around the outer surface of the organ are slits through which a sticky secretion might be secreted to assist the adhesion to and the carriage of pharate females.

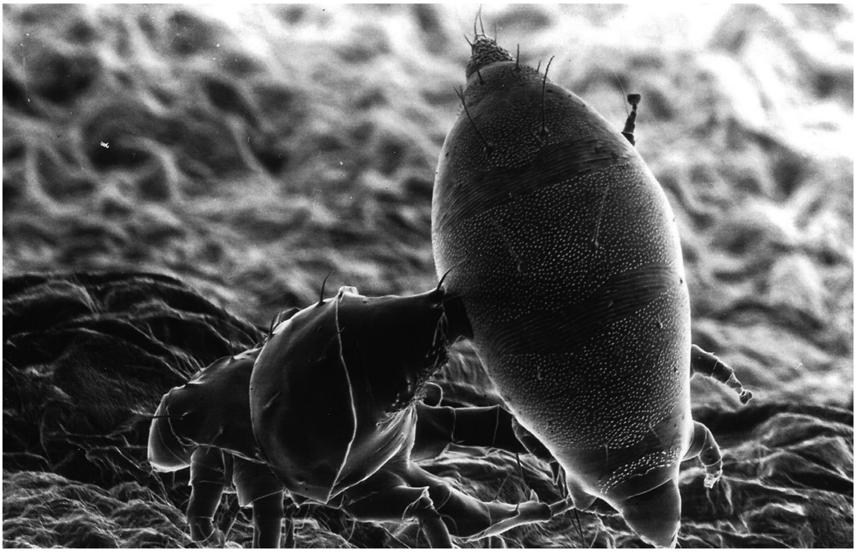

Fig. 1. S.E.M. of male carrying pharate female. The male places the pharate female at right angles to its body and carries it using the sucker

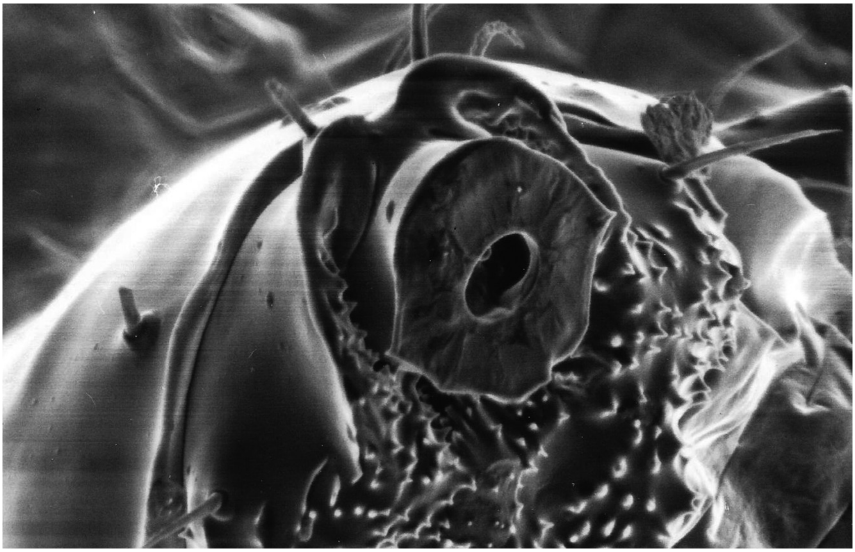

Fig. 2. S.E.M. illustrating the structure of the male sucker

It is already known that when pharate females emerge from their larval skins, the sexes copulate and produce eggs. Fertilized eggs give rise to females and unfertilized eggs to males, a process known as arrhenotoky. Hatching takes place when a split occurs along a suture line on the dorsal side of the egg (Fig. 3).

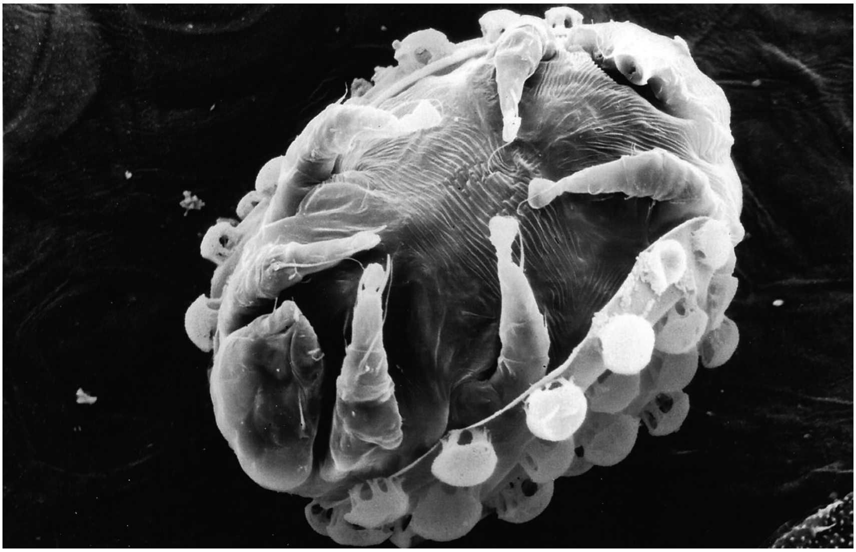

Fig. 3. S.E.M. showing the larval stage emerging from the egg.

Adhesive organs exist throughout the Phylum Arthropoda and there are many different forms of sucker that have been described in the Acari. For example, an extensive, complex caudal ventral sucker plate, made up of a number of suckers is found in the deutonymph (= hypopus) stage of astigmatid mites and is used for attachment to insects and other arthropods. Baker et al. (1987) have described the morphology of several types of these cuticular structures found on mites. The structure in of *P. latus* appears to be a genuine sucker and is used by males to carry pharate females inside their larval skin.

The egg is elliptical, translucent and around 90 µm in length and 60 µm wide. The upper surface is covered with around 30 protuberances which are evenly distributed. Each is about 8–10 µm across and stands on buttressed projections, like stilts or struts, attached and arranged around the base. They have open chambers, referred to as locular chambers (Fig. 4). Each protuberance appears white in SEMs, against the darker background of the egg surface, and the upper surface of each appears to be perforated with minute holes (pores) (Fig. 4).

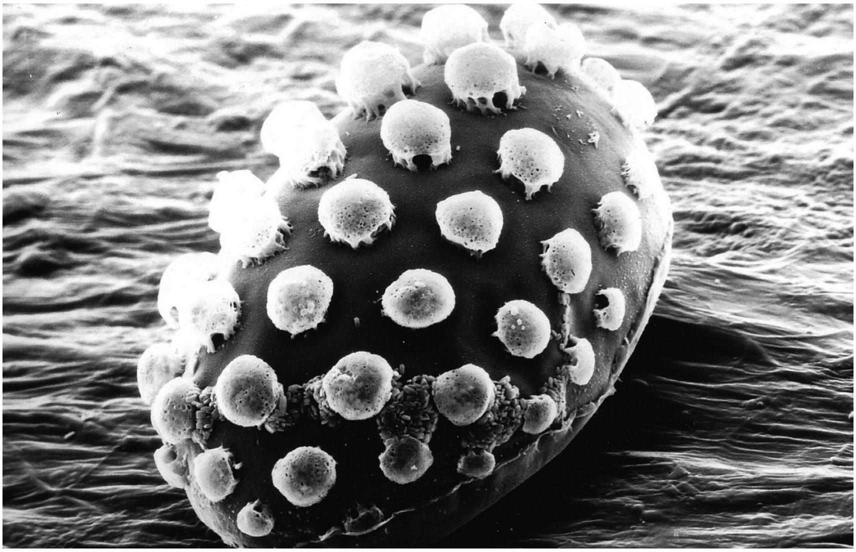

Fig. 4. S.E.M. showing the dorsal surface of the egg.

Plastron respiration is well known in aquatic insects and certain non-tracheate arachnids (Hebets and Chapman 2000) and plastrons have been reported on the eggs of a number of insect species (e.g. Hinton 1969); the subject is reviewed by Mill (1998). and A plastron is a gas film of constant volume that is held on the outside of the cuticle by hydrofuge hairs or cuticular projections The insect obtains oxygen by diffusion through this air store, the structure acting as a physical gill.

Hinton (1969) suggested that, in the majority of insect eggs, there is a meshwork in the chorion that holds a layer of gas and that the aeropyles can open above the egg surface on the apices of stalked aeropyles. Mill (1998) describes it similarly thus, "Many insect eggs have respiratory openings called aeropyles, which may be scattered evenly over the surface, arranged in bands, clustered anteriorly, or lie on the crest of longitudinal ridges or on the end of stalks".

However, information on mite eggs is not so well documented. Hinton (1971) reported on plastron respiration in the active stages of a mesostigmatid mite, *Platyseius italicus*, a predatory species commonly found in sewage Bacteria beds (Baker 1964) where it is frequently exposed to jets of water. It is here suggested that, in *Polyphagotarsonemus latus* the protuberances may comprise a discontinuous plastron. Whether the openings on the upper surface of the protuberances (Fig. 4) are pits or pores (aeropyles) has yet to be decided.

The locular chambers are believed to trap a pocket of air beneath them, as Callaini and Mazzini (1984) discuss, and thus provide a gas-water interface for gaseous exchange when the egg is covered by water. The eggs of this mite are undoubtedly subject to dew formation, heavy rain from time to time or the watering and high humidity maintained in greenhouses. These air stores would allow the eggs to be immersed by water for long periods and yet provide for the exchange of gases. As Mill (1972) states it, "When the animal is submerged the retained layer of gas has a constant volume and so oxygen will diffuse out of the surrounding water into this layer in order to preserve the equilibrium – provided of course that the oxygen tension in the surrounding water is greater than the partial pressure of oxygen in the film of gas".

Apart from the work of Martin (1991) and Montasser et al (2011) little work has been done on the fine structure of *P. latus* eggs. Witaliński (1993) using TEM and SEM techniques, has studied the structure of other mite eggs in detail but, compared to insects, little is known about plastron structure and function in this group. Martin (1991) was unable to suggest a satisfactory function for the 'tubercles' and noted "The possible function(s) and the mechanism of construction are fascinating questions as yet unresolved". Callaini and Mazzini (1984) believe that the locular chambers probably permit gaseous exchange, especially as air reserves in the event of immersion and/or additionally serve to protect the egg from dehydration. Witaliński (1993) believes they play a role in reducing water loss rather than in respiration. Montasser et al. (2011) differentiate between “sacs” and “tubercles”, on the egg surface of *P. latus*, the latter being present after the removal of the protruding upper part. Although no clear function was ascribed it was suggested, by these authors, that they may play a role in respiration. The present author agrees with this last interpretation but prefers to use the term discontinuous plastron to describe the structures and plastron respiration to describe their function.

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PLASTRONY I ORGANY PRZYCZEPNE – MORFOLOGIA FUNKCJONALNA STRUKTUR POWIERZCHNIOWYCH U *POLYPHAGOTARSONEMUS LATUS* (BANKS, 1904)

Streszczenie

Praca jest poświęcona strukturom i funkcjonowaniu organów przyczepnych u samców *Polyphagotarsonemus latus* oraz strukturze powierzchni jaj tego roztocza. W badaniach posłużono się mikroskopem skaningowym. Organy przyczepne służą samcom do przytrzymywania samic, a struktura widoczna na powierzchni jaj jest pozostałością plastronu.

Słowa kluczowe: S.E.M., roztocz, jajo, plastron, organy przyczepne