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On the ultrastructure and functional morphology of the male chelicerae (gonopods) in Parasitina and Dermanyssina mites (Acari: Gamasida)

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ABSTRACT

Males of Parasitina and Dermanyssina (Gamasida = Mesostigmata) have chelicerae modified to function as gonopods. The slit-like spermatotreme in the movable digit of the chela in males of Parasitina was studied in three species: in *Pergamasus quisquiliarum* and *Holoparasitus* sp. a rather simple slit is indeed present, whereas in *Vulgarogamasus kraepelini* the structure is represented by a fine duct traversing the movable digit. The spermatodactyl studied in two phytoseioid species (*Phytoseiulus persimilis*, *Blattisocius dentriticus*) of Dermanyssina is a slender process arising from the movable digit and containing a fine duct which is formed by cuticular folds. The spermatodactyl of these species thus differs remarkably from that described in *Veigaia* sp. The diversity of these structures seen in the few taxa studied up to now is discussed under functional and systematic aspects.

1. Introduction

In mites both direct and indirect sperm transfer has been observed, but gamasid mites display only direct sperm transfer, but without a true copulation (mediated by a penis) (e.g., Alberti and Coons, 1999; Alberti, 2006). Males introduce sperm cells, always after formation of a sac-like spermatophore, into the females through the female primary genital opening or through secondary insemination pores usually by means of the chelicerae (hence functioning as gonopods) (Krantz, 1978; Evans, 1992; Alberti and Coons, 1999 and references therein). As the chelicerae in males of gamasid mites are involved, besides in feeding activities, in sperm transfer, in more derived taxa like Parasitina and Dermanyssina the chelicerae show peculiar structures. These are likely adapted to a more precise manipulation of the spermatophores and related to peculiar specialized structures to receive the spermatozoa in the females and to different insemination modes. Females show a modified genital system (massive ovary provided with a nutritive tissue in Parasitina shaped to form a "lyrate organ" in Dermanyssina) and can be provided with peculiar specialized structures to receive the spermatozoa (sperm access system) in Dermanyssina. Hence insemination can occur through the primary genital opening (neotocospermy of Parasitina) or through secondary insemination pores (solenostomes) associated with the hind legs (podospermy of Dermanyssina) (Alberti and Coons, 1999; Alberti, 2002a,b).

Moreover, among Gamasida, those taxa provided with modified chelicerae show a displacement of the male genital opening in a presternal position to facilitate the transfer of the spermatophore to the gonopods.

In particular, in males belonging to Parasitina, the male chelicerae are characterized by the presence of a spermatotreme. This has been considered, according to light and scanning electron microscopy, as a rather simple longitudinal slit on the movable digit of the chelicerae that usually is enlarged compared with the corresponding female. On the other hand, males belonging to Dermanyssina present a free appendage or a fused process extending from each movable digit, the spermatodactyl (Krantz, 1978; Evans, 1992; Alberti and Coons, 1999).

Though behavioural observations have supported the idea that these structures are involved in collecting the spermatophores from the male genital opening and transferring them into the female body (e.g., Michael, 1892; Dosse, 1959; Young, 1968; Lee, 1974; Korn, 1982; Amano and Chant, 1978; Krantz and Wernz, 1979), their functional morphology is still poorly known (e.g., Michael, 1892; Young, 1968; Krantz and Wernz, 1979) with ultrastructural observations being scarce, dealing, until now, only with the spermatodactyls (Alberti et al., 2005; Di Palma et al., 2006, 2008).

Hence, a description of the morphology, fine structure and three-dimensional organization of these gonopodal modifications, with functional implications, is reported here for three species of Parasitina and two species of Dermanyssina.

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2. Materials and methods

In the present study males belonging to three species of Parasitidae, one of Phytoseiidae and one of Blattisociidae were used.

Parasitina – Parasitidae: *Pergamasus quisquiliarum* (G. Canestrini and R. Canestrini, 1882), *Holoparasitus* sp., *Vulgarogamasus kraepelini* (Berlese, 1905) collected in May 2006 in beech wood ("Eldena" nature reserve in East Greifswald, Germany).

Dermanyssina – Phytoseiidae: *Phytoseiulus persimilis* Athias-Henriot, 1957, bought from a commercial supplier (Neudorff Company, Germany).

Dermanyssina – Blattisociidae: *Blattisocius dentriticus* (Berlese, 1918) (taxonomy according to personal communication by G.W. Krantz; this species/genus has also been placed in Ascidae, e.g., Evans and Till, 1979 or in Phytoseiidae by, e.g., Karg, 1993) collected in Bari (Italy) in July 2000 from a lab-rearing of scale insects.

All specimens were dissected and prefixed in 3.5% glutaraldehyde in phosphate buffer (pH 7.4; 0.1 M) at 4 °C except for *B. dentriticus* which was dissected and prefixed in Karnovsky's (1965) fixative. After 2 h, the specimens were rinsed in buffer solution and subsequently post-fixed in 2% OsO_4-solution for 2 h and embedded in Spurr's resin after dehydration in graded ethanols. *B. dentriticus* was embedded in Araldite using propylenoxide as an intermedium. Ultrathin sectioning was performed with a Leica Ultracut UCT using Diatome diamond knives. The sections were double-stained with uranyl acetate and lead citrate (Reynolds, 1963) and investigated with a Zeiss EM 10 transmission electron microscope (TEM).

Some specimens of each species were processed accordingly for scanning electron microscopy and observations were performed on a Zeiss DSM 940A scanning electron microscope (SEM).

3. Results

3.1. Spermatotreme in three species of Parasitina (Parasitidae)

3.1.1. Pergamasus quisquiliarum

SEM observations (Fig. 1A,D) show the spermatotreme as a slit (about 30 μm long) penetrating the movable digit from the adaxial to the abaxial side.

Serial sections studied with TEM reveal that the slit starts distally on the adaxial surface of the movable digit without reaching the abaxial surface (Fig. 1B). It looks, in cross section, like a groove delimited by two thin rims of cuticle. More proximally, the groove gets wider and deeper (Fig. 1C) with one smaller rim in the middle of the groove and a thinner or narrower slit directed towards the abaxial surface of the movable digit (Fig. 1C).

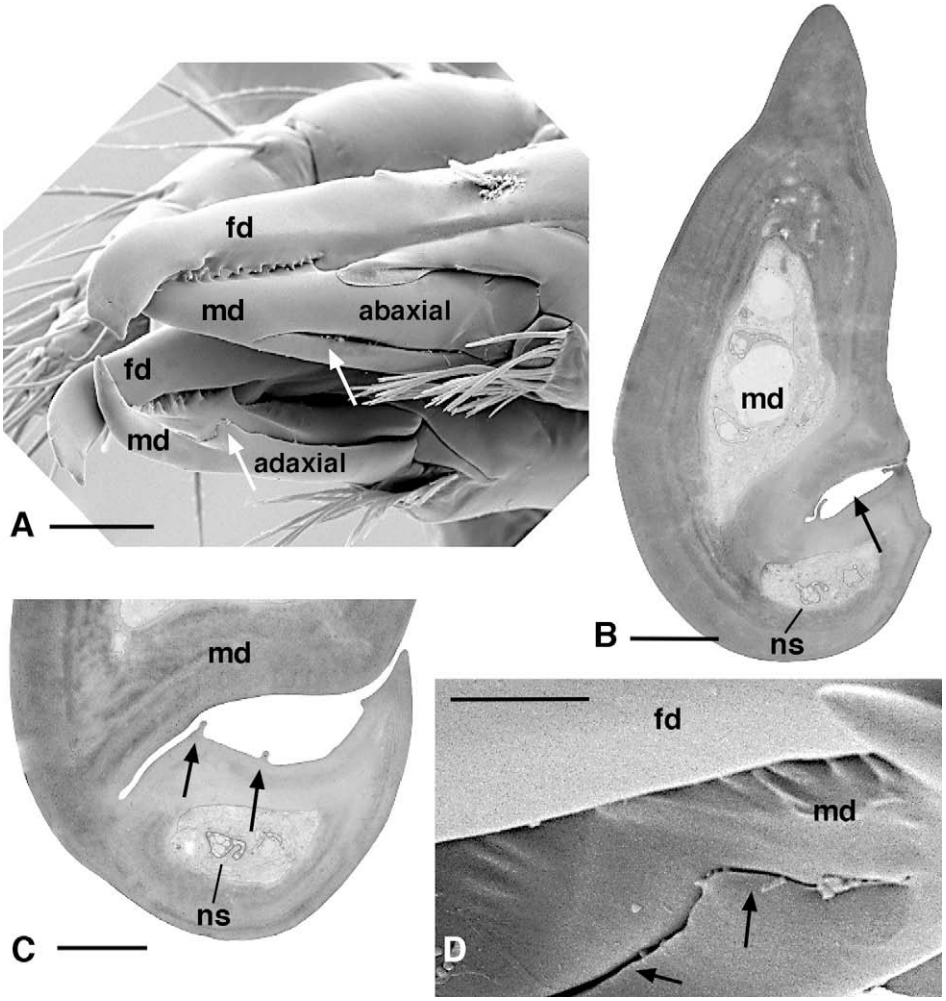

Fig. 1. (A–D) *Pergamasus quisquiliarum* spermatotreme. (A) SEM: overview of the chelicerae with the spermatotreme (the longitudinal slits (arrows) penetrating the movable digit from the adaxial to the abaxial surface). (B) TEM: distal cross section of the movable digit. The slit starts on the adaxial surface without reaching the abaxial one. Arrow points to the central groove. (C) TEM: more proximal cross section. Note that the groove is wider with two rims of cuticle (arrows) and a thinner slit directed towards the abaxial surface of the movable digit. (D) SEM: adaxial surface of the movable digit showing the spermatotreme (arrows). Abbreviations: fd, fixed digit; md, movable digit; ns, nervous structure. Scale bars: 30 μm (A); 5 μm (B); 2 μm (C); 10 μm (D).