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The coreine spermatheca: morphological structure and terminology (Heteroptera: Coreidae: Coreinae)

La espermateca tipo coreidos: estructura morfológica y terminología (Heteroptera: Coreidae: Coreinae)

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ABSTRACT

In order to introduce a forthcoming paper devoted to the different types of spermatheca within the Coreidae (Hemiptera: Heteroptera), the morphology of the cuticular parts of the coreine spermatheca is here described in detail and illustrated through the example of *Coreus marginatus* (Linnaeus, 1758), the type species of the type genus of the Coreinae, the subfamily comprising the majority of coreid bugs. Definition and terminology are given for the three morphologically and functionally distinct parts of the organ: (1) the apical seminal receptacle (sperm storage chamber) covered with the efferent ductules of the numerous glandular units forming the spermathecal gland; (2) the intermediate part (muscular pump apparatus) and its own distinct regions, distal, middle and proximal; (3) the spermathecal duct, either simple or with differentiated part along its length. Main variations of these different parts within the Coreinae are mentioned. The presence of two vaginal structures often associated with the coreid spermatheca is also briefly mentioned: the sclerotized ring encircling the parieto-vaginal gland and the fecundation groove.

Key words: Coreidae, Coreinae, spermatheca, morphology, terminology.

RESUMEN

Con el fin de introducir un trabajo próximo sobre los distintos tipos de espermatecas en los Coreinae, la estructura morfológica de la partes cuticulares de la espermateca tipo coréidos es descrita en detalle e ilustrada con el ejemplo de *Coreus marginatus* (Linnaeus, 1758), especie tipo de los Coreinae, la subfamilia más grande. Se presenta definición y terminología para las tres partes morfológicas y funcionales del órgano : (1) el receptáculo seminal apical (cámara de esperma), cubierto por los ductos eferentes de las numerosas unidades glandulares formando la glándula de la espermateca; (2) la parte intermedia (bomba muscular) y sus distintas regiones que son distal, mediana y proximal; (3) el canal eferente de la espermateca, que es simple o con una posible parte diferenciada a lo largo de su longitud. Se menciona el polimorfismo principal para cada parte. También se menciona brevemente la presencia de dos estructuras vaginales, a menudo asociadas con la espermateca tipo coréidos: el anillo esclerotizado encerrando la glándula parieto-vaginal y el canal de fecundación.

Palabras clave: Coreidae, Coreinae, espermateca, morfología, terminología.

In his fundamental work on heteropteran spermatheca, Pendergrast (1957) was the first to describe the coreid spermatheca in four species, *Acantholybas brunneus* (Breddin, 1899), *Anoplocnemis* sp., *Coreus marginatus* (Linnaeus, 1758) and *Coriomeris denticulatus* (Scopoli, 1763). At that time, the family Coreidae included the Alydidae, Rhopalidae and Stenocephalidae, now separate families. On the basis of the spermathecal characters, he pointed out that the Coreidae s.l. appears a very distinct group. Indeed, the subsequent comparative studies revealed a confusing diversity in the form, often complex, of the coreid spermatheca. After Štys (1964) who studied the Agriopocorini, the most important contributions were that of Kumar (1965) who described and illustrated the spermatheca of 14 species belonging to 11 tribes. Schaefer (1964, 1965, 1968) studied the spermatheca in many tribes but regrettably his illustrations were excessively simplified. Subsequent authors gave new data on Colpurini (Ahmad 1970), Coreini and Gonocerini (Vavřínova 1988), and species belonging to various tribes (Lee *et al*. 1989; Li 1996a, b, c). Moulet (1993, 1995) made additional important histological observations on various poorly known structures of the spermatheca especially in Coreini and Prionotylini.

In the meantime, many taxonomic works also have significantly contributed to our knowledge of the general shape of the spermatheca in numerous genera representing various tribes. They are too numerous to be here cited completely; they include in particular the papers of Brailovsky and co-workers on the tribes Nematopodini (Brailovsky and Barrera 1986; Brailovsky *et al*. 1994), Hypselonotini (Brailovsky 1985, 1987, 1988, 1990; Brailovsky and Cadena 1992), Colpurini (Brailovsky 1994, 1995, 1996, 1997, 1998, 2000; Brailovsky and Barrera 1996). Other significant contributions include those on the tribes Coreini, Dasynini and Prionotylini (Dolling 1973, 1974), Gonocerini (Van Reenen 1976), Colpurini (Dolling 1987), and Placoscelini (Dolling and Casini 1988; Packauskas 2006 as Stenoscelideini). Dolling (1979, 1986) documented the spermatheca extensively within the subfamily Pseudophloeinae.

Several authors, particularly Kumar (1965), Schaefer (1965, 1968) and Packauskas (2006), found the characters of the spermatheca very useful to highlight relationships between the coreid tribes, or to reveal existence of misplaced species within otherwise homogeneous groups. We fully agree with this opinion and for that reason we started a comparative study on the structure of the coreid

spermatheca within the four subfamilies (Coreinae, Hydarinae, Meropachyinae and Pseudophloeinae) and most tribes of the family (Pluot-Sigwalt and Moulet, in prep.). This study is nearly completed for the subfamily Coreinae comprising currently 33 tribes (Livermore *et al*. 2016).

In this paper – dedicated to our colleague and friend Harry Brailovsky, a world expert in Coreidae and a very productive entomologist – we want to describe as an introduction to our forthcoming paper, the basic structure of the coreine spermatheca in order to give an accurate terminology. Terminology is of special importance in comparative studies and before providing an overview of the diversity of the spermatheca within the Coreidae, it is necessary to precise the general structure of the spermatheca and to provide the same names to homologous structures.

Although its spermatheca has already been documented by a number of authors (Pendergrast 1957; Schaefer 1965; Vavřínova 1988; Moulet 1993), we have chosen to describe the coreine spermatheca on the example of *Coreus marginatus* (Linnaeus, 1758), the type species of the type genus of the Coreinae – a subfamily that contains the majority of coreid bugs –, because it exhibits clearly most of the particularities of the coreid type of spermatheca. After this description we will mention the main variations of the spermatheca observed within the Coreinae.

MATERIAL AND METHODS

The spermatheca of *Coreus marginatus* was studied in dried specimens and thus only the cuticular intima of the organ is here described. About one hundred coreine species belonging to 68 genera representing 27 tribes have also been examined; they will be discussed in our forthcoming paper (Pluot-Sigwalt and Moulet, in prep.). We follow the classification of the Coreidae presented by Livermore *et al*. (2016).

Methods including staining by chlorazol black and light microscopical examination of the spermatheca, has been described elsewhere (Pluot-Sigwalt and Lis, 2008).

The terminology used is mostly that of Dupuis (1955, 1970) and for several terms that of Moulet (1993).

RESULTS

In Coreinae, as in most Pentatomomorpha, the spermatheca opens through the dorsal wall of the posterior part of the vagina often called genital chamber or gynatrium (Štys 1962). It exhibits three morphologically and functionally distinct parts (Dupuis, 1970): the capsula seminalis, the pars intermedialis and the ductus receptaculi; we have anglicised below these Latin terms. The spermatheca is also functionally associated with two vaginal structures common in several pentatomomorphan families: the fecundation groove and the sclerotized ring; both are briefly described below.

I. The spermatheca and associated structures in *Coreus marginatus*

The spermatheca (Figs. 1, 2)

1) The apical **seminal receptacle** which is the sperm storage chamber, is referred to as "distal bulb" by almost all authors. It is kidney-shaped, sclerotized, pigmented and thick-walled. The receptacle is surrounded by a **spermathecal gland**, a thick layer of glandular units, each provided with an efferent cuticular ductule (Fig. 2). These numerous ductules persist after the KOH treatment and demonstrate the presence of the spermathecal gland.

2) The **intermediate part** (Fig. 2), referred to as "pump apparatus" by most authors, is a modified part of the spermathecal duct connecting the seminal receptacle with the spermathecal duct. In living specimens, it is surrounded by muscular fibers and functions as a sperm pump (see Moulet 1993, Fig. 5). It is composed of three distinct regions:

a) The ***distal region*** of the intermediate part is a ***tightly coiled mass*** ("canal contourné" of Moulet 1993), a convoluted tubule which follows the seminal receptacle. It is sclerotized, strongly pigmented and thick-walled. As indicated by previous authors (Pendergrast 1957; Kumar 1965, Schaefer 1964, 1965, 1968; Moulet 1993), muscle attachment is realized on this region; thus the tightly coiled mass replaces functionally the specialized structure called ***distal flange***, i.e. a cuticular flange on which the muscular fibers are attached distally, present in many Pentatomomorpha.

b) The ***middle region*** is a ***flexible zone*** (Fig. 2), a non-sclerotized, non-pigmented, short straight section having probably an important role in the functioning of the spermatheca because it may be strongly distorted during the action of muscles (see Pluot-Sigwalt and Lis 2008: Fig. 3). Although this segment is always present in the ground plan of the pentatomomorphan spermatheca, it is rarely mentioned or illustrated.

c) The ***proximal region*** of the intermediate part is a greatly enlarged portion of the spermathecal duct, the ***ampulla*** (see Moulet, 1993), on which mucle fibers are inserted and acts as the ***proximal flange*** present in many Pentatomomorpha (Pendergrast, 1957; Kumar 1965, Schaefer, 1964, 1965, 1968; Moulet, 1993). At this level, the non-pigmented and non-sclerotized cuticular wall is thickened and greatly reduces the lumen, forming a kind of funnel-shaped valve; this structure has been named ***fretum*** (Moulet 1993).

3) The **spermathecal duct**, in a narrow sense, is simple and rather short, without any specialized region; the non-pigmented and non-sclerotized cuticular intima is thin and soft. Only, the basal part of the duct slightly widens and forms a U-bend when opening into the vaginal wall.

The **spermathecal opening** into the vagina is simple, i.e. it is not associated with any particular structure (thickening, sclerite or pigmentation).

The associated structures

The **fecundation groove** (Fig. 1) is a narrow dorsal groove formed by the vaginal wall, running from the opening of the spermathecal duct toward the median oviduct. It is membranous and inconspicuous.

The **sclerotized ring** (Fig. 1). A single, wide and thin ring is present on the vaginal wall; sinuously curved it extends over the entire width of the vagina.

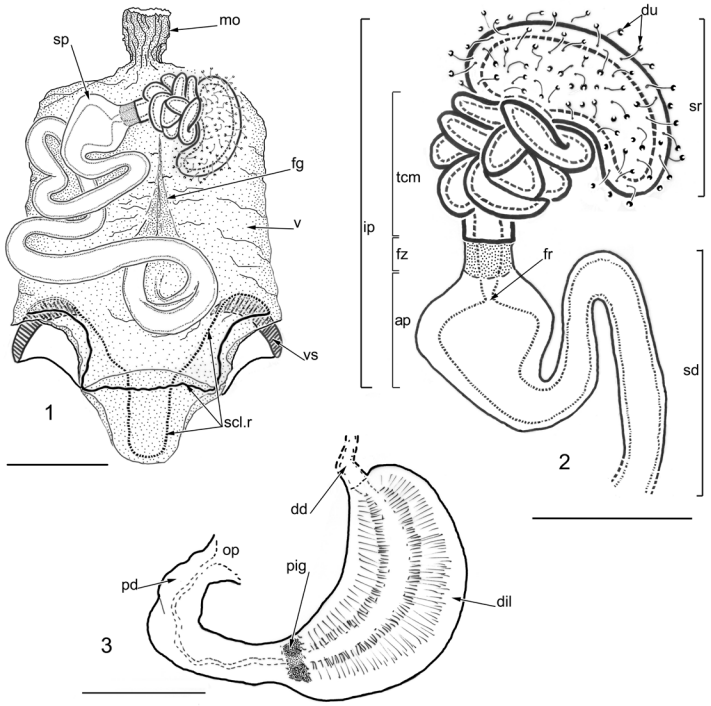
II. Main variations within the subfamily Coreinae

According to the literature and our own observations, all parts of the spermatheca appear highly variable within the Coreinae.

The seminal receptacle, usually sclerotized and pigmented, may be spherical, ovoid, elongate and apically ovoid, or kidney-shaped. All these forms may be observed in one tribe: see for instance the Hypselonotini (Brailovsky 1985a, 1987a, 1988, 1990; Brailovsky and Melendez 1989; Brailovsky and Cadena 1992).

The intermediate part appears the most variable region of the coreine spermatheca. The tightly coiled mass which is constantly sclerotized and pigmented may be either a huge mass of tight coils or restricted to one or two coils, sometimes loosely coiled, or even almost straight as pointed by Kumar (1965). In the latter case, instead of the coiled part there is a flange (*distal flange*) as in Stenoscelideini (see Packauskas 2006), a tribe synonymized with the Placoscelini in the Online Classification of the Coreoidea (Livermore *et al*. 2016). The non-pigmented flexible zone is only variable in length; it may appear as a short section (as in *Coreus*) or it can be significantly longer. The basal ampulla is either greatly swollen or reduced, its diameter only hardly surpassing the diameter of the spermathecal duct. The basal ampulla may be also transformed into a flange as in most representatives of Hypselonotini studied by Brailovsky (1985, 1987, 1988, 1990).

The usually non-pigmented and soft spermathecal duct may be simple (i.e. with no differentiation along its length), more or less wide, long, convoluted; also, the cuticular intima exhibits various aspects and structures according to genera and tribes. In many taxa, the spermathecal duct exhibits some differentiated part (swelling, expansion, diverticulum), the most frequent being a clear **dilation** (Fig. 3) along the duct. The cuticular intima is usually modified at the level of the dilation, considerably thickened and the wall may be strongly striated (Fig. 3) or the internal surface may extend into numerous long cuticular digitations toward the lumen (see the fine histological sections given by Souza et al. 2015 for *Leptoglossus*). Schaefer (1965) thought that the dilation was a specialization of the vagina and called it "bursa copulatrix", the part into which the



Figures 1, 2. *Coreus marginatus* (Coreini). 1. dorsal view of the female ectodermal genital tract showing the spermatheca and associated structures. 2. details of the three main parts of the spermatheca. Scale bar: 0.5 mm. Figure 3. *Sundarus regalis* (Westwood, 1842) (Hypselonotini), aspect of the dilation of the spermathecal duct, a differentiation of the duct common in several American genera and frequently illustrated by Brailovsky (1985, 1987, 1988, 1990). Scale bar: 1 mm. **Abbreviations**: **ap**, ampulla; **dd**, distal duct; **di**, dilation; **du**, ductules; **fg**, fecundation groove; **fr**, fretum; **fz**, flexible zone; **ip**, intermediate part; **mo**, median oviduct; **op**, opening of the spermatheca into the vagina; **pd**, proximal duct; **pig**, pigmentation; **sc.r**, sclerotized ring; **sd**, spermathecal duct; **sp**, spermatheca; **sr**, seminal receptacle; **tcm**, tightly coiled mass; **v**, vagina; **vs**, vaginal sclerite.

phallus penetrates during copulation. But the dilation, indeed often basally located on the spermathecal duct, is clearly a specialization (apparently glandular) of the duct itself.

The spermathecal opening into the vagina is consistently membranous, devoid of any particular structure. Thus the aperture is usually concealed by numerous folds of the vaginal wall and rarely distinct.

A single unpaired sclerotized ring is widespread in Coreinae. It was first observed within the tribe Agriopocorini (Štys 1964), and then illustrated or described in representatives of several other tribes: Cloresmini (Kumar 1965), Colpurini (Dolling 1987), Coreini (Moulet 1993), Homoeocerini (Lee *et al*. 1989), Prionotylini (Moulet 1993).

The fecundation groove is probably widespread within the Coreinae as in some other pentatomomorphan families (Pluot 1970 in Pyrrhocoridae; Tsai et al. 2011 in Scutelleridae). Nevertheless, the structure cannot be easily observed as it is entirely membranous. For this reason, it was not systematically studied.

CONCLUSION

The coreine spermatheca exhibits a strange and complex organization and a perplexing diversity. To our knowledge the kidney-shaped seminal receptacle, the tightly coiled mass and the large ampulla of the intermediate part seem unique to the Coreinae (and very probably also to the Meropachyinae) among the Pentatomomorpha. But in the same time the coreine spermatheca exhibits also the tripartite condition of the pentatomorphan spermatheca, thereby facilitating the comparison of homologous structures. The first task is to recognize with confidence the three main regions of the spermatheca: seminal receptacle, intermediate part and spermathecal duct. But we have to admit that in some cases, it is not so easy to recognize the intermediate part, complex and variable within the Coreinae, particularly when no cuticular mark indicates the insertion points of the muscle fibers.

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Abedus herberti. Mexico: Sonora: Municipio de Moctezuma: Rancho San Fernando, E side of Sierra de la Madera, 17.4 km (by air) W of Huásabas, 20.5 km (by air) ENE of Moctezuma. Photographer Stephen.L. Minter