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Additional data on the spermatophore of *Arianta arbustorum* (Gastropoda: Pulmonata: Helicidae)

A. A. Schileyko*

Abstract

An illustrated description of the spermatophore of the land pulmonate snail *Arianta arbustorum* is presented. The exchange of spermatophores between partners apparently does not take place simultaneously. The spermatophores of *Arianta arbustorum* (Ariantinae) and *Helix pomatia* (Helicinae) are compared.

Key words: Gastropoda, Helicidae, Ariantinae, *Arianta*, reproduction, spermatophore.

Zusammenfassung

Eine illustrierte Beschreibung der Spermatophore der Landlungenschnecke *Arianta arbustorum* wird vorgestellt. Es wird gezeigt, dass der Austausch von Spermatophoren zwischen den Partnern augenscheinlich nicht ganz gleichzeitig erfolgt. Ein Vergleich der Spermatophoren der *Arianta arbustorum* (Ariantinae) und *Helix pomatia* (Helicinae) wird präsentiert.

Introduction

The presence of spermatophores is a characteristic feature for several families of land pulmonte mollusks. These spermatophores sometimes have a very complex structure and are therefore used in taxonomy as a diagnostic character (for example, in Milacidae – see Wiktor 1981).

Data on the spermatophores of Helicidae are scarce. Currently, the structure of the entire spermatophore in representatives of Helicidae is known for only two species: *Helix pomatia* (Linnaeus, 1978) (Meisenheimer 1907; Lind 1973; corresponding illustration was redrawn by Tompa 1984), and *Arianta arbustorum* (Linnaeus, 1758) (Hofmann 1923; Baminger & Haase, 2001; Beese et al. 2006). In addition, fragmented data on the helicid spermatophores are known for four other species: *Cryptomphalus aspersus* (Müller, 1774), *Levantina djulfensis* (Dubois de Montpéreux, 1840), *L. escheriana* (Bourguignat, 1864), and *Caucasotachea calligera* (Dubois de Montpéreux, 1840) (Schileyko 1978).

Material and methods

On 20.08.2014 near Sulzkarsee Lake (Austria, Styria, 1600 m asl), during an excursion in the framework of the Workshop Alpine Landsnails 2014, Helmut Sattmann found a pair of *Arianta arbustorum* in copula; Katharina Jaksch photographed them. The weather

* Anatoly A. Schileyko ,A.N. Severtsov Institute of Ecology and Evolution of Russian Academy of Sciences, Leninski prosp. 33, Moscow 119071, Russia. – asch0829@gmail.com

Fig. 1. A pair of *Arianta arbustorum* in copula (courtesy Katarina Jaksch).

that day was rainy, with a dense fog, the air temperature was 13–15 °C. One of these photos was presented in my recent article (Schileyko 2014: 185, fig. 15), and one of the present reviewers suggested including it here as well (Fig.1).

The snails were fixed in 70% ethanol after holding them for 6 hours in water at 35–40 °C. I studied the reproductive tract of both specimens using manual dissection.

Results and discussion

In both fixed specimens the large, tongue-like atrial stimulator and everted atrium are visible (Fig. 2). At the base of the stimulator there is a tiny orifice of the penis, and in one of the specimens (specimen No. 1) the posterior part of a spermatophore protruded from the opening of the vagina (Fig. 2A).

The spermatophore consists of two well-defined parts: head ("sperm container", after Baminger & Haase 2001 and Beese et al., 2006) and tail thread (Fig. 2B). The head of the spermatophore is formed in the epiphallus, whereas the posterior part (tail thread) is formed in the flagellum.

The head has very thin, semitransparent walls, through which the white sperm mass is clearly visible; the wall surface bears numerous very shallow, irregular wrinkles (although the wrinkling may be a result of fixation). Baminger & Haase (2001) and Beese et al. (2006) found a thin filament on the apex of the spermatophore head; I was unable to detect such a filament. It may have been lost in the process of dissection.

The tail thread of the spermatophore is solid (without internal cavity) and is shaped like a long ribbon, slightly twisted and folded. In one specimen (No. 1) the tail thread was almost straight; the head was located in the lower part of the diverticle of the spermathecal

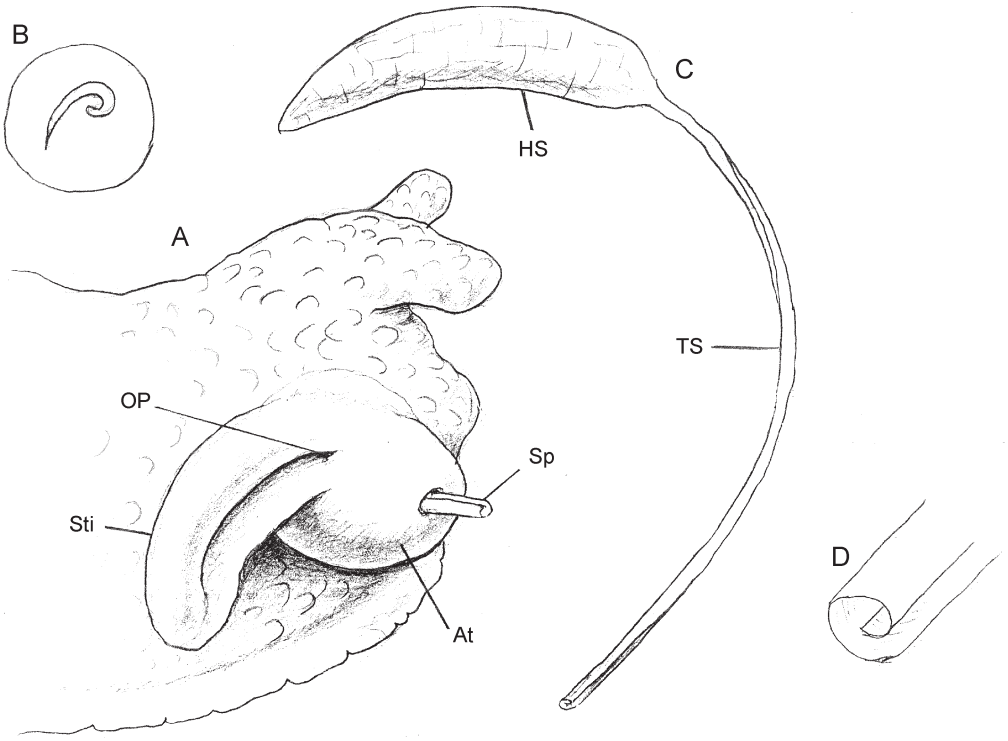

Fig. 2. Details of copulatory apparatus of *Arianta arbustorum* (specimen No. 1). A, anterior part of snail; atrium and stimulator everted. B, cross-section of flagellum showing shape of tail of spermatophore. C, spermatophore. D, end of tail thread, much enlarged. At, everted atrium; HS, head of spermatophore; OP, orifice of penis; Sp, spermatophore; Sti, stimulator; TS, tail of spermatophore.

duct. In the other specimen (No. 2) the head of the spermatophore extended into the upper section of the diverticle, whereas the tail thread was coiled in a spiral and located entirely in the lower portion of the diverticle (Figs. 3, 4).

The exchange of the spermatophores in the studied specimens of *A. arbustorum* apparently did not take place simultaneously: in specimen No. 1 the spermatophore was in the process of penetrating the vagina and the diverticle of spermathecal duct, whereas in specimen No. 2 the spermatophore was already entirely within the diverticle. During copulation, one of the specimens clearly played the role of a donor ("male") and, after transferring its own spermatophore, it became a recipient ("female").

Note that the spermatophores of *Arianta* and *Helix* differ markedly. In *Arianta* the spermatophore head is very large and well-defined, whereas in *Helix* it, after LIND (1973) and TOMPA (1984), is minute and is followed by a thin neck, a somewhat enlarged body, and a long tail thread. Martin Haase (pers. comm. April 2015) suggests that the head and neck of *Helix* in LIND (1973) correspond to the head filament of BAMINGER & HAASE (2001), and that the body in the former corresponds to the sperm container of the latter.

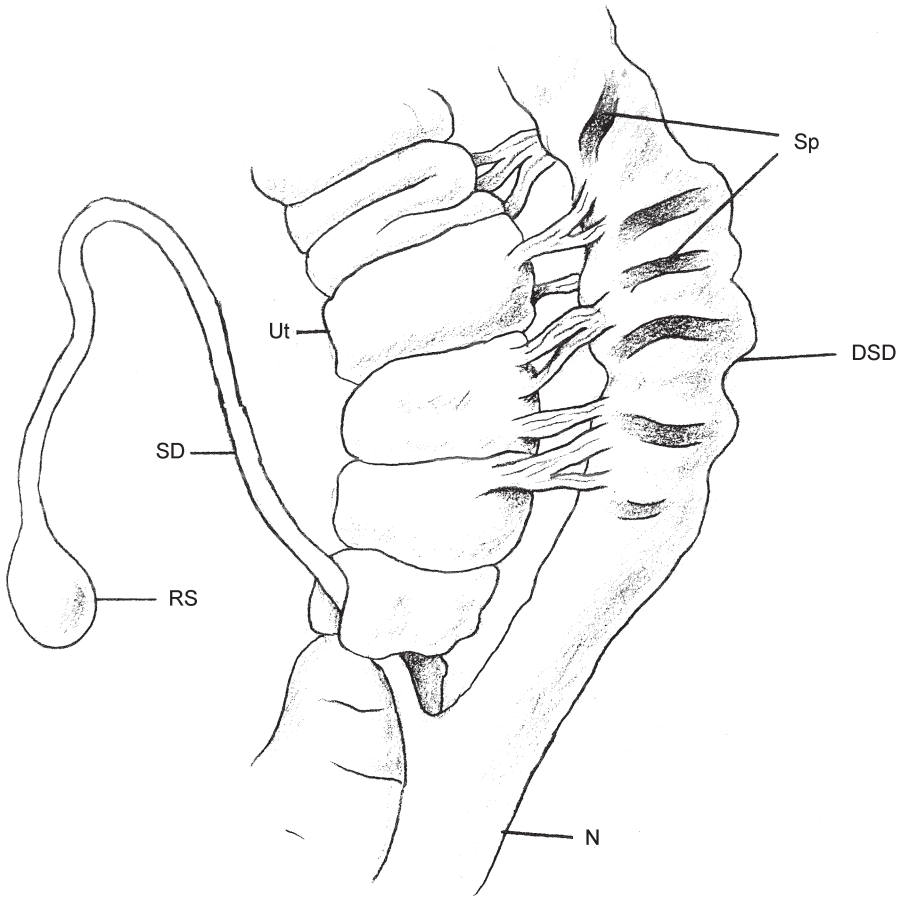

Fig. 3. Part of reproductive tract of *Arianta arbustorum* (specimen No. 2). DSD, diverticle of spermathecal duct containing coiled tail of spermatophore.; N, neck of spermathecal duct; RS, reservoir of spermatheca; SD, spermathecal duct proper; Sp, fragments of spermatophore visible through wall of diverticle; Ut, uterus.

The structure of the tail thread in *Helix* and *Arianta*, however, is very similar. Since the tail thread is formed in the flagellum, the cross-section through this organ shows the structure of the mold of the spermatophore thread (Fig. 2B). I made cross-sections through the flagella of several members of Ariantinae [*Faustina faustina* (Rossmässler, 1835), *Liburnica setosa* (Férussac, 1832), *Dinarica pouzolzi* (Deshayes, 1830), *Helicigona lapicida* (Linnaeus, 1758), *Drobacia banatica* (Rossmässler, 1838), *Cochlopupa obtusa* (Draparnaud, 1805)]: in all studied species the mold of the tail thread has the same structure.

Moreover, a very similar structure of the tail thread of the spermatophore is present in another group of Helicoidea sensu lato, namely in Hygromiidae, in particular in *Oscarboettgeria euages* (O. Boettger, 1883), *Stenomphalia pisiformis* (L. Pfeiffer, 1852), *Monacha fruticola* (Krynicki, 1833), *M. caucasicola* (Lindholm, 1913), and *Paedhoplita buamica* B. Tzvetkov & E. Tzvetkova, 1943 (Schileyko 1978).

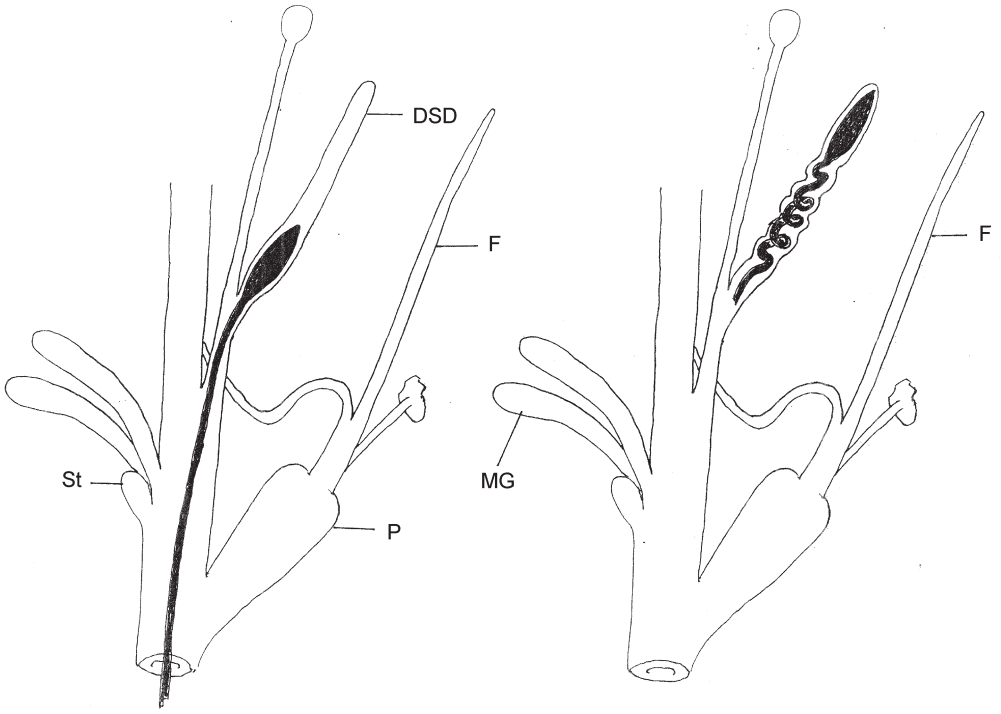

Fig. 4. Position of spermatophore (black) in reproductive tract of two specimens of *Arianta arbustorum*: No. 1 (left) and No. 2 (right). DSD, diverticle of spermathecal duct; F, flagellum; MG, mucus glands; P, penis; St, stylophore. Schematized.

During copulation the head of the spermatophore is directed to the diverticle. As BAMINGER & HAASE (2001: 356) supposed, "The head filament probably guarantees that the spermatophore is not pushed too far up into the diverticulum so that the end of the tail would get too close to the entrance of the bursal duct." At the same time, the tip of the tail thread (as demonstrated for *Levantina djulfensis*, a member of the Helicinae) turns up into the spermathecal duct (SCHILEYKO 1978: 328-329, fig. 443).

Accordingly, such a tail thread structure is probably characteristic for almost all helicoid mollusks and plays an important role in moving the spermatozoa in the genital ducts of the recipient. The pathway of the spermatophore after the exchange of the spermatophores is as follows. The spermatophore head, as stated above, is directed toward the diverticle. Then the content of the head flows into the reservoir of the spermatheca (HOFMANN 1923; LIND 1973; SCHILEYKO 1978; BAMINGER & HAASE, 2001). The tail thread plays a key role here. I interpret that the narrow open canal that is formed from the longitudinal folding of the tail thread creates a capillary effect, promoting the movement of the seminal fluid along the ducts of the spermathecal complex.

This warrants a comparison with the situation in *Levantina djulfensis* (see above): in that species the path of the seminal fluid from the diverticle into the spermathecal duct along the slit that runs along the tail thread is direct. Importantly, in Hygromiidae, which

lack a diverticle, the tail thread has the same structure: even here seminal fluid must be transported from the spermatheca (which is a gametolythic organ) into the fertilization chamber ("Befruchtungstasche" of German authors) (L. Schileyko & A. Schileyko 1975).

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