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THE PENIAL STALK OF THE *ZONITOIDES NITIDUS* (O. F. MÜLLER, 1774) (GASTROPODA: PULMONATA: GASTRODONTIDAE) SPERMATHECAL DUCT AS AN ALLOSPERM CONTAINER

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ABSTRACT: The penial stalk of the *Zonitoides nitidus* (O. F. Müller, 1774) spermathecal duct is found to be an additional allosperm container. Inside the penial stalk of spermathecal duct, sperm was observed in hemiphallic snails only. At the same time, some specimens had sperm inside the penis. The atrial stalk of spermathecal duct is the distal part of spermathecal duct.

KEY WORDS: *Zonitoides nitidus*, reproductive system, penial stalk, spermathecal duct

INTRODUCTION

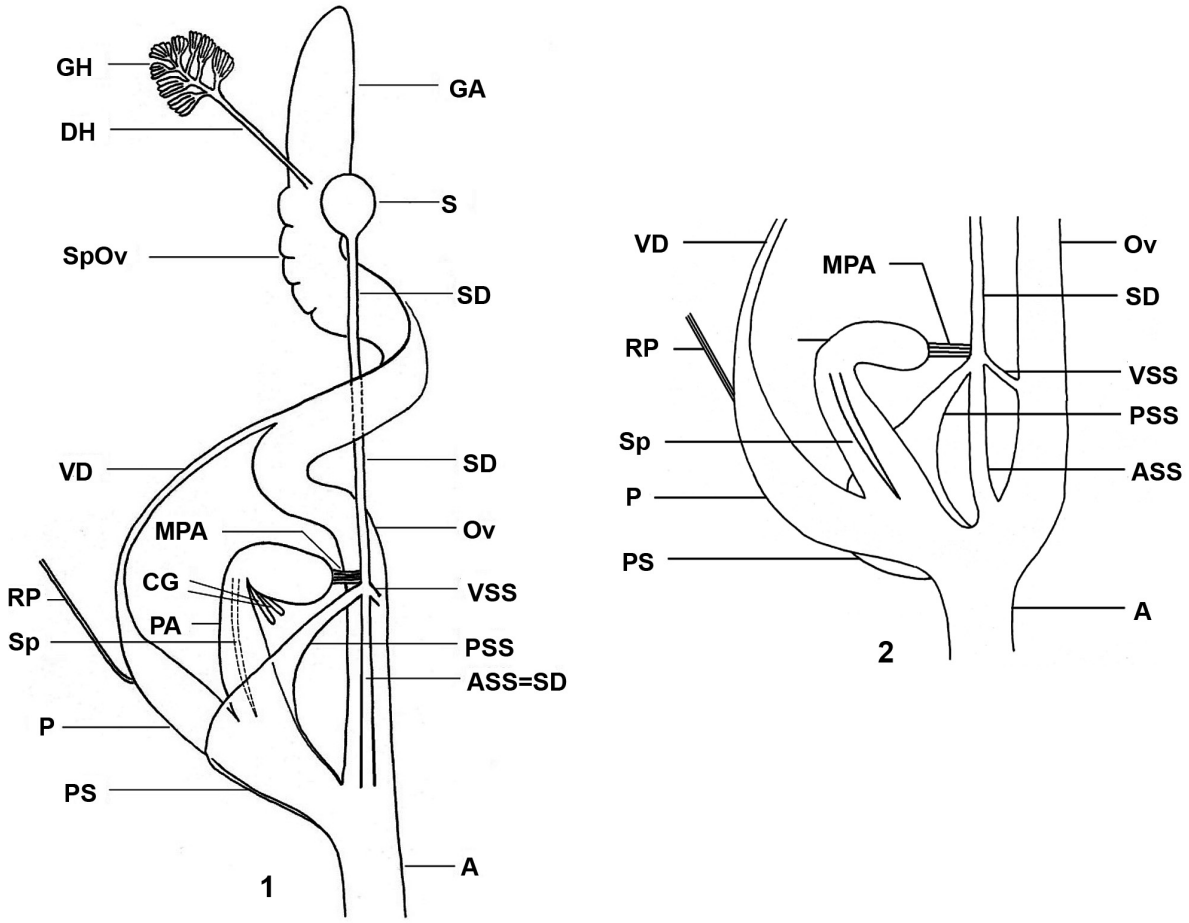
The reproductive system of *Zonitoides nitidus* (O. F. Müller, 1774) has been of interest to malacologists for a long time (BAKER 1928, PILSBRY 1946, RIEDEL 1966, JORDAENS et al. 2003). The genitalia of this species have a number of interesting features. The snails can be euphallic or hemiphallic. Besides, the penis has a special appendix, and a spike was found inside it. It is considered to be a love-dart analogue.

The spermathecal duct structure is of special interest. In the *Zonitoides* anatomy, the main characteristic feature is the division of the spermathecal duct into two to three separate branches. According to the terminology proposed by YAKOVLEV (2005), those are called the penial, the vaginal, and the atrial stalks (Figs 1, 2). SHILEYKO (1972) has shown that the penial stalk does not open into the penis but is only attached to it. In its distal part, it abruptly widens and turns into a connective tissue sheath that covers the distal parts of the penis and its appendix. There is a cavity under this sheath. SHILEYKO (1972) suggests that this cavity serves as an additional container for the sperm or for the regulation of the liquid amount in the spermatheca, because the spermatheca itself is very small (SHILEYKO 1972).

YAKOVLEV (2005) made a series of cross-sections of the distal part of genitalia. He came to a conclusion that all the snails had three stalks in their spermathecal ducts but some had their atrial stalk underdeveloped and consisting only of a connective tissue strand coming close to the atrium but not opening into it. In the case of its underdevelopment, the atrial stalk thickness was only 20 to 30 μm, and because of that, it was often left undetected during dissection.

YAKOVLEV (2005) suggested that all the spermathecal duct stalks were hollow tubes connecting to the oviduct (according to YAKOVLEV, to the vagina) (Fig. 3). Near the oviduct, they all combined into a single morphological structure consisting of the independent ducts under the common connective tissue cover. According to YAKOVLEV (2005), the atrial spermathecal duct stalk did not open into the atrium but was just attached to it. It was the vaginal stalk of spermathecal duct that he believed to be the true spermathecal duct. The proof was the sperm found by YAKOVLEV (2005) in the vaginal stalk of spermathecal duct.

None of the 19 individuals examined by YAKOVLEV (2005) had sperm in the atrial and penial stalks of spermathecal duct. That led him to question SHILEYKO's (1972) hypothesis on the penial stalk of spermathecal duct as the excess allosperm container. This study was aimed at solving this problem.



Figs 1–2. *Zonitoides nitidus*. Structure of genitalia: 1 – general view, diagrammatic; 2 – longitudinal section of distal parts of genitalia, diagrammatic. A – atrium, ASS – atrial stalk of spermathecal duct, CG – coronary glands, DH – hermaphrodite duct, GA – albumen gland, GH – hermaphrodite gland, MPA – muscles of penial appendix, Ov — oviduct, P – penis, PA – penial appendix, PS – penial sheath, PSS – penial stalk of spermathecal duct, RP – penial retractor, S – spermatheca, SD – spermathecal duct, Sp – spike, SpOv – spermoviduct, VD – spermiduct, VSS – vaginal stalk of spermathecal duct

MATERIAL AND METHODS

The reproductive structures of 27 specimens of *Z. nitidus* were examined. The snails were collected from typical habitats of the species, selected for research in the following Regions of Russia (Table 1): Tver, Moscow, Novgorod (collected by E. V. SHIKOV) and Ulyanovsk (collected by R. R. GAINULLIN). The snails were drowned in water, initially at room temperature (20–23°C) for 24 hours, then at 40–50°C for 1 hour, and preserved in 70% ethyl alcohol. The shells were dissolved in 10% hydrochloric acid. Dissection was conducted under the MBS-10 binocular microscope.

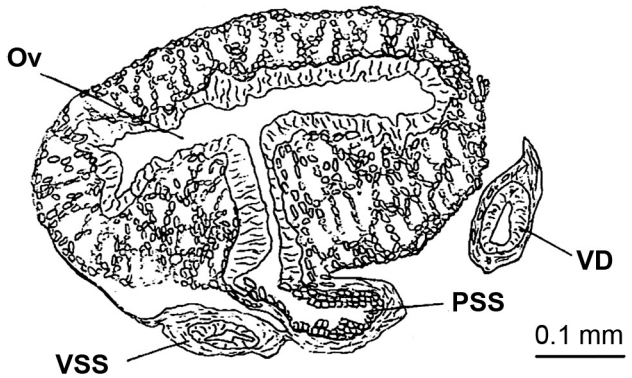


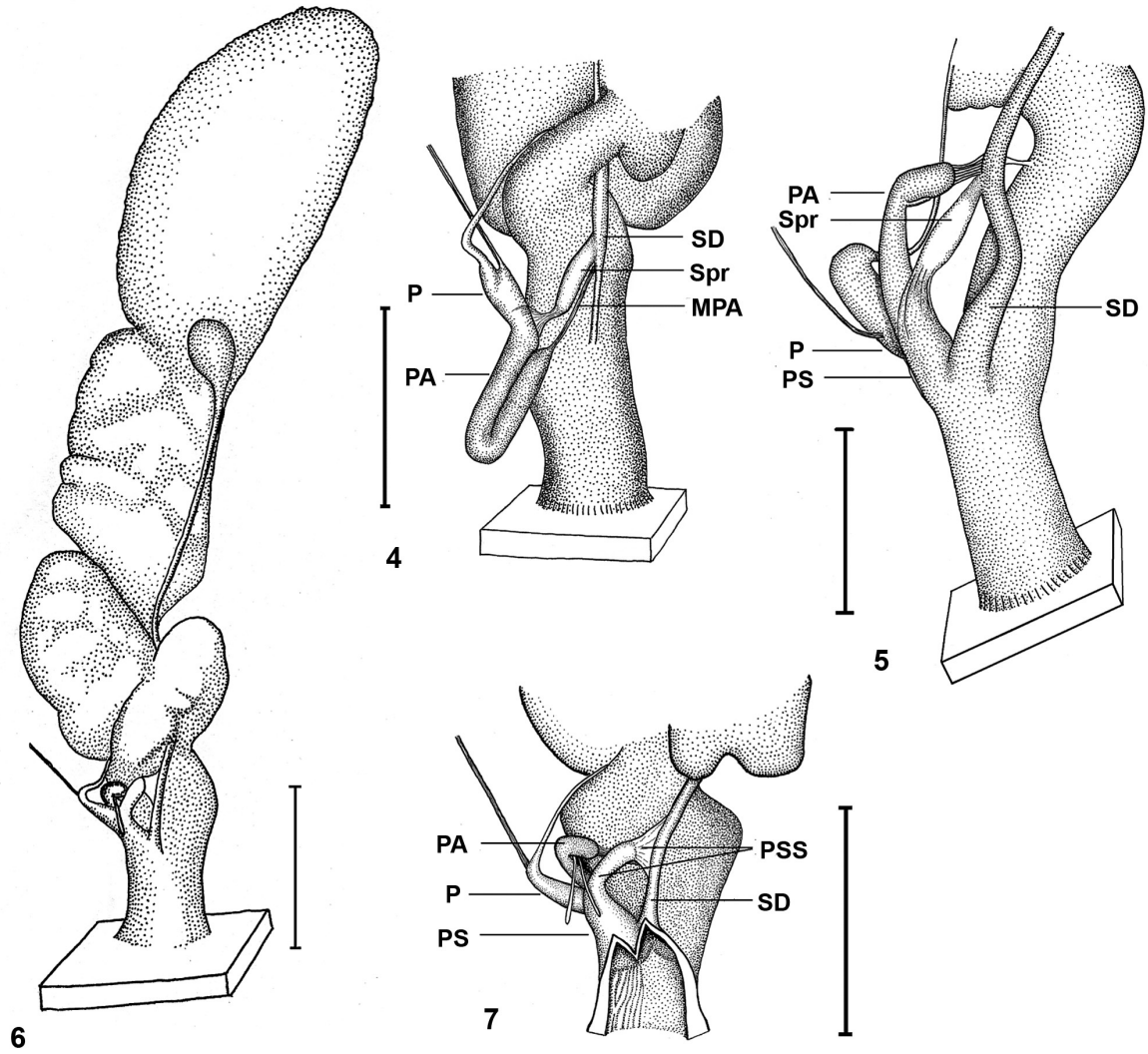
Fig. 3. Penial stalk attached to vagina (YAKOVLEV 2005). Explanations as in Fig. 1

RESULTS AND DISCUSSION

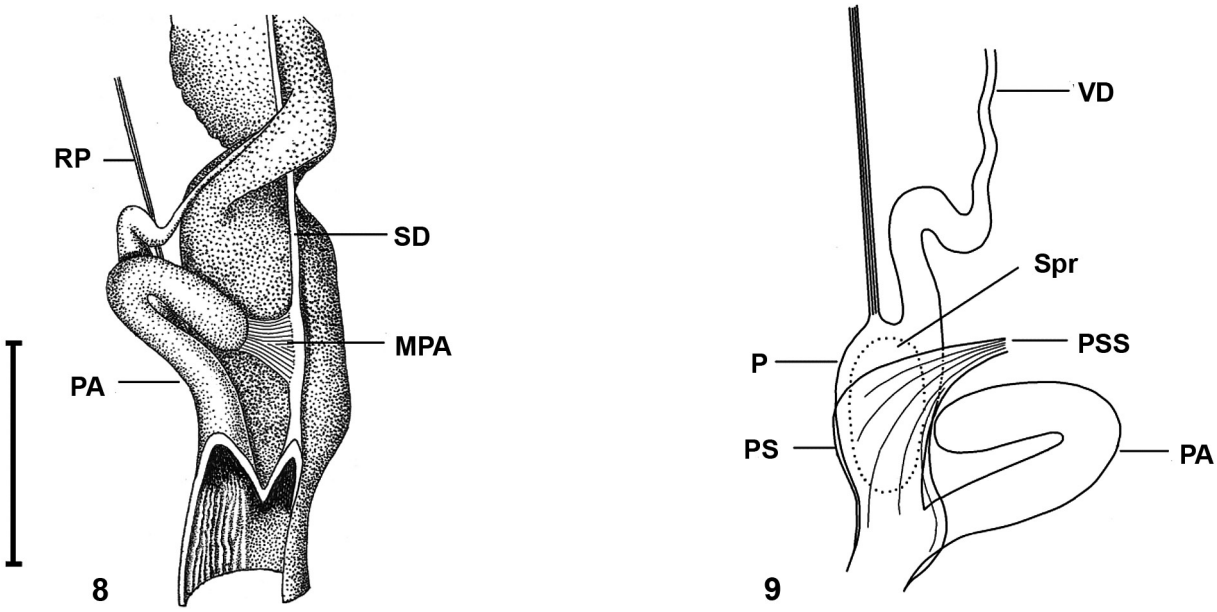
A white substance that I believe to be allosperm was repeatedly found in the penial stalks of spermathecal ducts. Figures 4–7 show the sperm filling the proximal, medial, and distal parts of the penial stalk of spermathecal duct. In the latter case, the penis sheath is considerably distended and covers a large part of the penis (Fig. 7). Inside the penial stalk of spermathecal duct, sperm was observed in hemiphallic snails only. At the same time, some of the snails had sperm inside the penis (Figs 8, 9).

Table 1. *Zonitoides nitidus* – material examined

Site number	Sampling site	Total number of dissected snails	Number of snails with allosperm
1	Tver Region, Rameshki District, thickets of *Alnus incana* along a brook near Ivitza village, water edge. May 31, 1967	4	1
2	Novgorod Region, Lyubytino District, swamp with *Alnus incana* and *Salix* on large hummocks, *Calla palustris* thickets, 2 km E of Bereznyak 2 village. August 26, 1976	4	0
3	Tver Region, Peno District, *Carex* covered island on Lake Vitbino. June 22, 1979	6	2
4	Moscow Region, Chekhov District, bottom of a gully covered with high grass and deciduous forest near Meshcherskoye village. May 29, 2008	4	1
5	Tver City, wet meadow on Tmaka River bank. September 15, 2010	3	0
6	Ulyanovsk Region, Inzensk District, pond bank with willows and tall herbs (*Urtica dioica, Aegopodium podagraria)* near Yulovka village. May 29, 2010	6	3



Figs 4–7. *Zonitoides nitidus*. Allosperm in penial stalk of spermathecal duct: 4 – sperm in proximal part of penial stalk of spermathecal duct (middle part of spermiduct inflated because it is also filled with sperm, penial appendix turned to atrium, which is its natural though unusual position); 5 – sperm in medial part of penial stalk of spermathecal duct; 6 – hemiphallic reproductive system; 7 – genitalia fragment, same individual as in Fig. 6, with sperm in medial and distal parts of penial stalk of spermathecal duct, penial sheath inflated. Figs 4, 6, 7 – village Yulovka; Fig. 5 – Lake Vitbino. Scale bar 1 mm. For explanations see Fig. 1, Spr – sperm



Figs 8–9. Evidence of spermatogenesis in hemiphallic *Zonitoides nitidus*: 8 – distal part of reproductive system with atrium dissected longitudinally, village Yulovka; 9 – same specimen as in Fig. 8, penial appendix bent to the right, sperm mass inside penis indicated with dashed line. Scale bar 1 mm. For explanations see Fig. 1, Spr – sperm

The longitudinal sections of the atrium and atrial stalk of spermathecal duct showed that the atrial stalk opened into the atrium (Figs 7, 8). Therefore, the distal part of the female genitalia should be regarded as the oviduct.

The internal wall of the atrium can be relatively smooth or covered with longitudinal folds, depending on the physiological state of the animal. Some of the folds enter the atrial stalk of spermathecal duct. In my opinion, it is this stalk that is the true spermathecal duct. This does not match YAKOVLEV's (2005) conclusion based on his cross-sections of the genitalia (Fig. 10). A cross-section made somewhat lower down would probably reveal the place where the atrial stalk of the spermathecal duct opens into the atrium.

The penial stalk of spermathecal duct of euphallic *Z. nitidus* can be reduced and can be relaxed. In the first case the penial sheath fits the distal part of the penis and its appendix tightly. In the second case the penial sheath is loose, and a large cavity is seen under its soft folds.

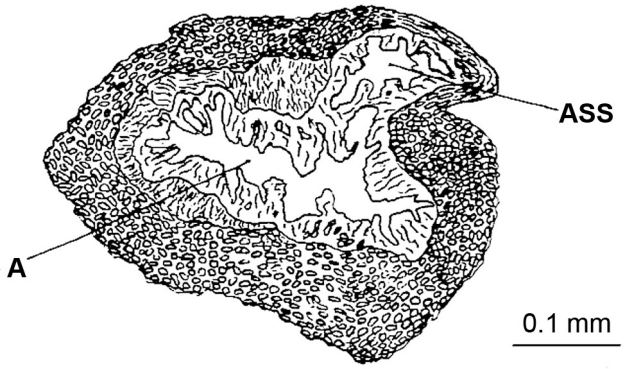


Fig. 10. Cross-section of atrium and atrial stalk of spermathecal duct (YAKOVLEV 2005). For explanations see Fig. 1

Considerable amounts of sperm were found in the penial stalks of spermathecal ducts of some specimens. This confirms SHILEYKO's (1972) hypothesis on the penial stalk of spermathecal duct functioning as an allosperm container.

There is no evidence of sperm coming from the penial stalk back into the spermathecal duct. Therefore, it can be assumed that the excessive amount of sperm in the penial stalk of the spermathecal duct is needed for the regulation of the whole *Z. nitidus* reproductive system. MAMATKULOV (2007) has shown that in the Clausiliidae the spermatheca not only serves sperm storage for later fertilisation, but is also a special gametolytic organ. It serves as a part of the complex endocrine-humoral mechanism which controls the gastropod syngenesis. The excess of sperm undergoes lysis and is absorbed into the hemolymph. The products of the sperm lysis modify gametogenesis. The hermaphrodite gland starts producing eggs. In my opinion, the same takes place in *Z. nitidus*.

There is no doubt that the atrial stalk of spermathecal duct can function as a part of the spermathecal duct only when it is fully developed. When the atrial stalk is only a connective tissue strand, it cannot serve as a duct. However, this fact alone is not enough to assume that the distal part of spermathecal duct is its vaginal stalk. Some specimens of *Z. nitidus* have their vaginal stalk underdeveloped as well.

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REFERENCES

BAKER H. B. 1928. Minute American Zonitidae. Proc. Acad. Nat. Sci. Philad. 80: 1–44.

JORDAENS K., VANRIEL P., BACKELJAU T. 2003. Molecular and morphological discrimination between the pulmonate landsnails *Zonitoides nitidus* and *Zonitoides excavatus*. J. Moll. Stud. 69: 295–300. doi: 10.1093/mollus/69.4.295

MAMATKULOV A. L. 2007. Osobennosti razmnozheniya nazemnykh mollyuskov semeystva Clausiliidae: reproduktivnyye tsikly i funktsionalnaya morfologiya polovogo apparata: Abstract. Candidate in biological Science Thesis. M., IEEP RAS 2007.

PILSBRY H. A. 1946. Land mollusca of North America (North of Mexico). Vol. II. Part I. Acad. Nat. Sci., Philadelphia.

RIEDEL A. 1966. Zonitidae (excl. Daudebardiinae) der Kaukasusländer (Gastropoda). Ann. Zool. 24: 1–303.

SHILEYKO A. A. 1972. Analiz osnovnykh chert organizatsiyi *Zonitoides nitidus* v svyazi s voprosom o sistematicheskom range Gastrodontinae (Gastropoda, Pulmonata, Stylommatophora). Proc. Zool. Mus. Moscow State Univ. 12: 145–155.

YAKOVLEV A. A. 2005. Organizatsiya protoka semyapriyemnika *Zonitoides nitidus* (Müller, 1774) (Gastropoda, Pulmonata, Gastrodontidae). Ruthenica 15: 61–64.

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