

Review

Beyond the mouse model: Using *Drosophila* as a model for sperm interaction with the female reproductive tract

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Abstract

Although the fruit fly, *Drosophila melanogaster*, has emerged as a model system for human disease, its potential as a model for mammalian reproductive biology has not been fully exploited. Here we describe how *Drosophila* can be used to study the interactions between sperm and the female reproductive tract. Like many insects, *Drosophila* has two types of sperm storage organs, the spermatheca and seminal receptacle, whose ducts arise from the uterine wall. The spermatheca duct ends in a capsule-like structure surrounded by a layer of gland cells. In contrast, the seminal receptacle is a slender, blind-ended tubule. Recent studies suggest that the spermatheca is specialized for long-term storage, as well as sperm maturation, whereas the receptacle functions in short-term sperm storage. Here we discuss recent molecular and morphological analyses that highlight possible themes of gamete interaction with the female reproductive tract and draw comparison of sperm storage organ design in *Drosophila* and other animals, particularly mammals. Furthermore, we discuss how the study of multiple sperm storage organ types in *Drosophila* may help us identify factors essential for sperm viability and, moreover, factors that promote long-term sperm survivorship.

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Contents

1. Introduction	724
2. Seminal receptacle	725
2.1. Gross morphology of seminal receptacle	725
2.2. Insights into the possible function of the seminal receptacle epithelium	725
2.3. Arrangement and motility of sperm in seminal receptacle	727
3. Spermathecae	728
3.1. Morphology of spermatheca	728
3.2. Spermatheca secretion may be involved in sperm maintenance	728
3.3. Arrangement and motility of sperm in spermatheca	729
4. Uncovering female molecules that promote sperm viability	730
4.1. Preservative role of antioxidants	730
4.2. Maintaining osmotic homeostasis in gametes and their environment	733
4.3. Preservative role of antimicrobial peptides in the female reproductive tract	733
4.4. Nourishing sperm	734

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5. Concluding remarks	735
Acknowledgement	736
References	736

1. Introduction

Reproduction involves interaction between male- and female-derived molecules and cells at many levels. In addition to direct sperm-egg interactions, equally critical interactions occur between gametes and molecules that either comprise the seminal fluid or are produced by the epithelia and glandular tissues of the female reproductive tract. In *Drosophila*, the female reproductive tract can be subdivided into sections: the upper reproductive tract, consisting of the ovaries and oviducts, and the lower reproductive tract, consisting of the sperm storage organs, accessory glands, and uterus (Fig. 1A). Each of these regions plays a different and essential role in gamete interactions. The lower reproductive tract is the site of two processes critical to reproduction: sperm management (storage, maintenance, and release from storage) and fertilization. Thus, it is the site where most of the sperm-female reproductive tract interactions occur.

Females in taxa ranging from insects to mammals have evolved sperm storage mechanisms [1]. However,

interesting differences exist across taxa. Different organisms store different amounts of sperm for different lengths of time. Furthermore, stored sperm may be motile or nonmotile and stored in closed or open reservoirs. Understanding the bases for these differences may give us insights into the mechanisms that underlie sperm storage and sperm-female reproductive tract interactions.

Female *Drosophila melanogaster* store ~20% of the 4000 to 5000 sperm transferred during mating [2–4], from which they can produce 600 to 800 progeny over a 3-week period [5]. Thus, female sperm storage plays a vital role in reproduction. How viable sperm are maintained after transfer to the female is still a mystery. Whereas sperm-female interactions have been shown to play an important role in sperm storage in mammals, little is known about sperm-female interactions in *Drosophila*. *Drosophila* females have two types of sperm storage organs: paired spherical spermathecae and a single elongate, tubular seminal receptacle [6,7] (Fig. 1). Although sperm enter both types of organs during mating, 65% to 80% of stored sperm reside in the

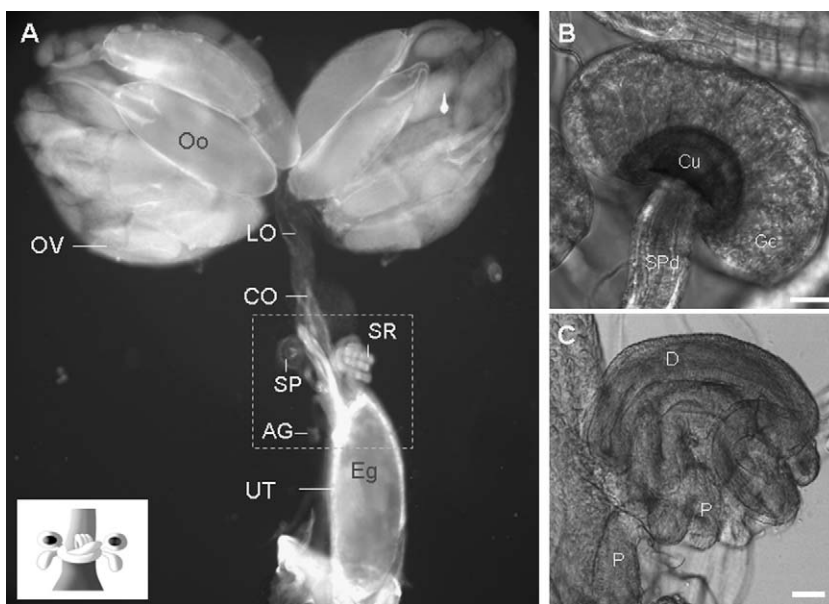


Fig. 1. The *Drosophila* female reproductive tract. (A) Bright-field microscopy image of mated female reproductive tract; dashed square represents the lower reproductive tract, which includes the spermatheca, seminal receptacle, posterior part of the common oviduct, and anterior part of the uterus (modified after [13]); note the egg (Eg) in the lower reproductive tract, ready for fertilization or during fertilization; drawing of the lower reproductive tract shown in inset. Bright-field higher magnification of (B) spermatheca and (C) seminal receptacle. Oocyte (Oo), ovary (OV), lateral oviducts (LO), common oviduct (CO), seminal receptacle (SR), spermatheca (SP), accessory glands (AG), uterus (UT), proximal (P), distal (D), cuticle (Cu), spermatheca duct (SPd), glandular cell (Gc). Scale bar = 20 μ m.

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