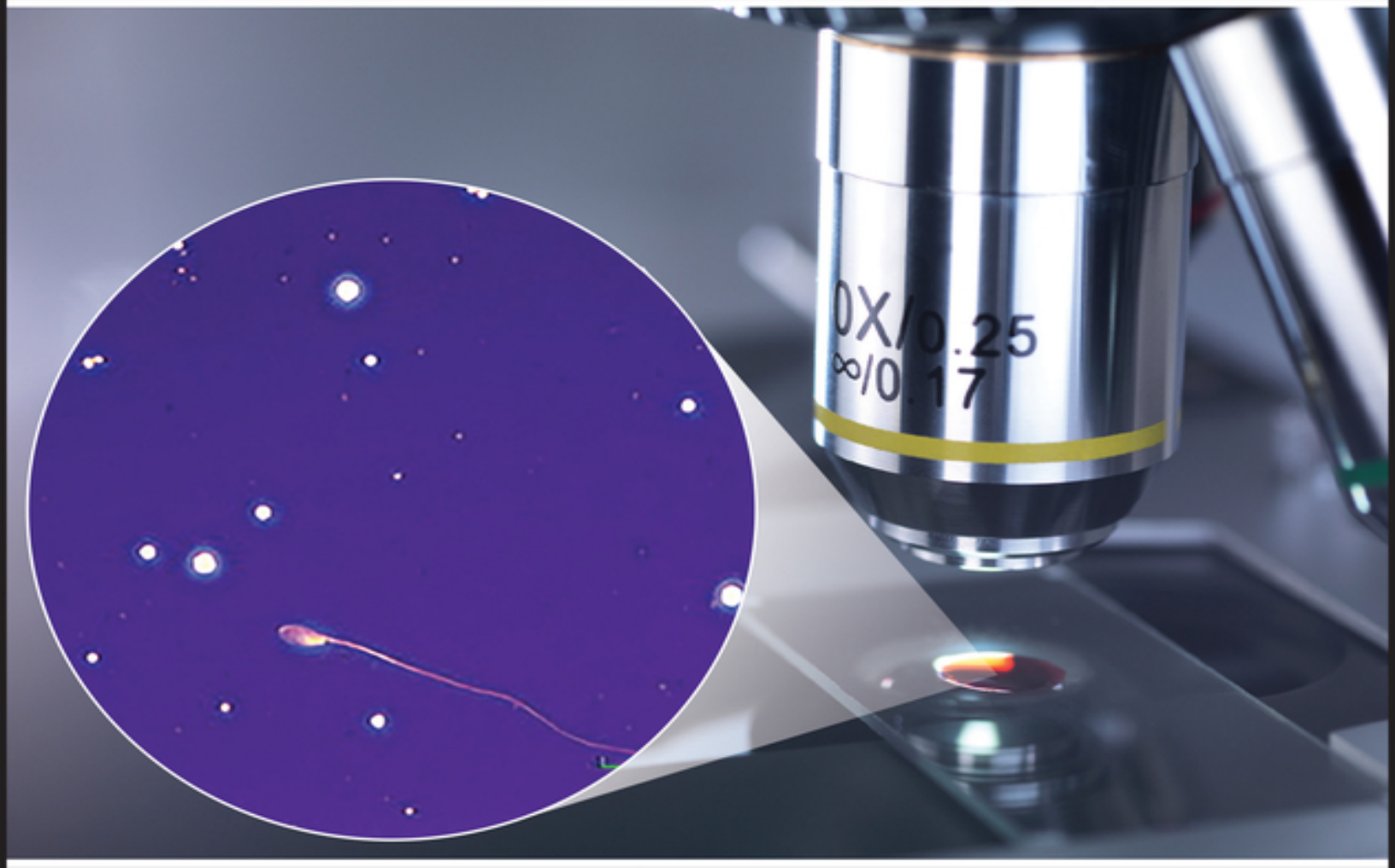
Sperm Morphology of Domestic Animals

Jennifer Koziol and Chance Armstrong



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Sperm Morphology of Domestic Animals

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WILEY Blackwell

This edition first published 2022

Registered Office
John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA

Editorial Office
111 River Street, Hoboken, NJ 07030, USA

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Library of Congress Cataloging-in-Publication Data applied for

ISBN: 9781119769767 (hardback)

Cover Design: Wiley
Cover Image: Courtesy of J.H. Koziol, Westend61/Getty Images

For RLC and DFW who taught us to never be satisfied and complacent with the status quo

Preface

Sperm Morphology of Domestic Animals has been written to further the understanding of morphologic assessment in the dog, stallion, bull, buck, and ram. This text is directed toward veterinary students and practitioners. Morphologic evaluation of sperm is a confusing part of the fertility examination. Ample images and figures have been added to provide real-time support during semen evaluation. The authors sincerely hope the added imagery will help provide clarity to a complex and often confusing portion of fertility assessment. Morphologic evaluation of sperm is an ever-evolving area of theriogenology, and this text has been written with the latest information from the current literature.

The authors would like to thank their mentors and other leaders in the field of theriogenology that inspire excellence in all that they set out to accomplish. This text would not have been possible without the generous support from Wiley.

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/koziol/sperm

The website includes:

- Teaching PowerPoints

Introduction

Sperm evaluation provides a noninvasive method to evaluate testicular and epididymal function, providing information similar to that gained by a testicular biopsy. An abnormal spermiogram with supporting evidence from the history and physical exam can give insights into reasons for abnormal testicular function, and consequently allow formation of a prognosis for recovery or potential treatment. When an abnormal spermiogram is found, the types and number of abnormalities combined with history regarding environment, nutrition, and health status can be used to compile a reason for spermiogram disturbances noted. The veterinarian can then use that information to make a diagnosis and prognosis for recovery.

An awareness of the mechanism of sperm transport in the female reproductive tract aids in understanding the relationship between sperm quality and fertility and consequently the level of defects that can be tolerated and still maintain reasonable pregnancy rates. The cervix, uterus, and uterotubal junction all reduce the number of abnormal sperm that can reach the site of fertilization. The cervix filters sperm with tail defects, while severely deformed heads are filtered at the level of the cervix, uterus, and uterine tubes. However, the filter system is not perfect and some sperm abnormalities may still reach the oocyte and induce fertilization [1, 2].

Three main criteria should be taken into account when evaluating abnormal sperm morphology: (i) abnormalities of the nucleus that allow ovum penetration and zona reaction but not fertilization or embryonic development *cannot* be tolerated at levels >15–20% without subsequent decrease in pregnancy rate; (ii) abnormalities of the

acrosome and sperm tail do not interfere with the ability of normal sperm to fertilize ova and therefore can be tolerated at levels up to 25%; (iii) a least 70–75% of spermatozoa should be normal [3] . The types and percentages of defects should be taken into consideration in both natural and artificial mating systems.

I.1 Spermatogenesis

A thorough understanding of normal and abnormal spermatogenesis facilitates understanding and interpretation of a spermiogram (description of sperm morphology noted during evaluation) (Figures I.1–I.4). The testis is largely composed of seminiferous tubules and interstitial tissue. The latter is located between the seminiferous tubules and consists primarily of Leydig cells, which produce and secrete steroid hormones, as well as vascular and lymph vessels that supply the testicular parenchyma. Seminiferous tubules arise from primary sex cords and contain germinal cells, as well as Sertoli cells, which support and nurture production of sperm. Sertoli cells form tight junctions, creating the most important portion of the blood–testis barrier [4] . Spermatogenesis occurs primarily in the tubulus contortus section of the seminiferous tubules. These tubules are surrounded by contractile peritubular cells that promote flow out of the tubulus contortus into the rectus (straight portion) of the seminiferous tubule. Both ends of each tubule are connected with the rete testis.

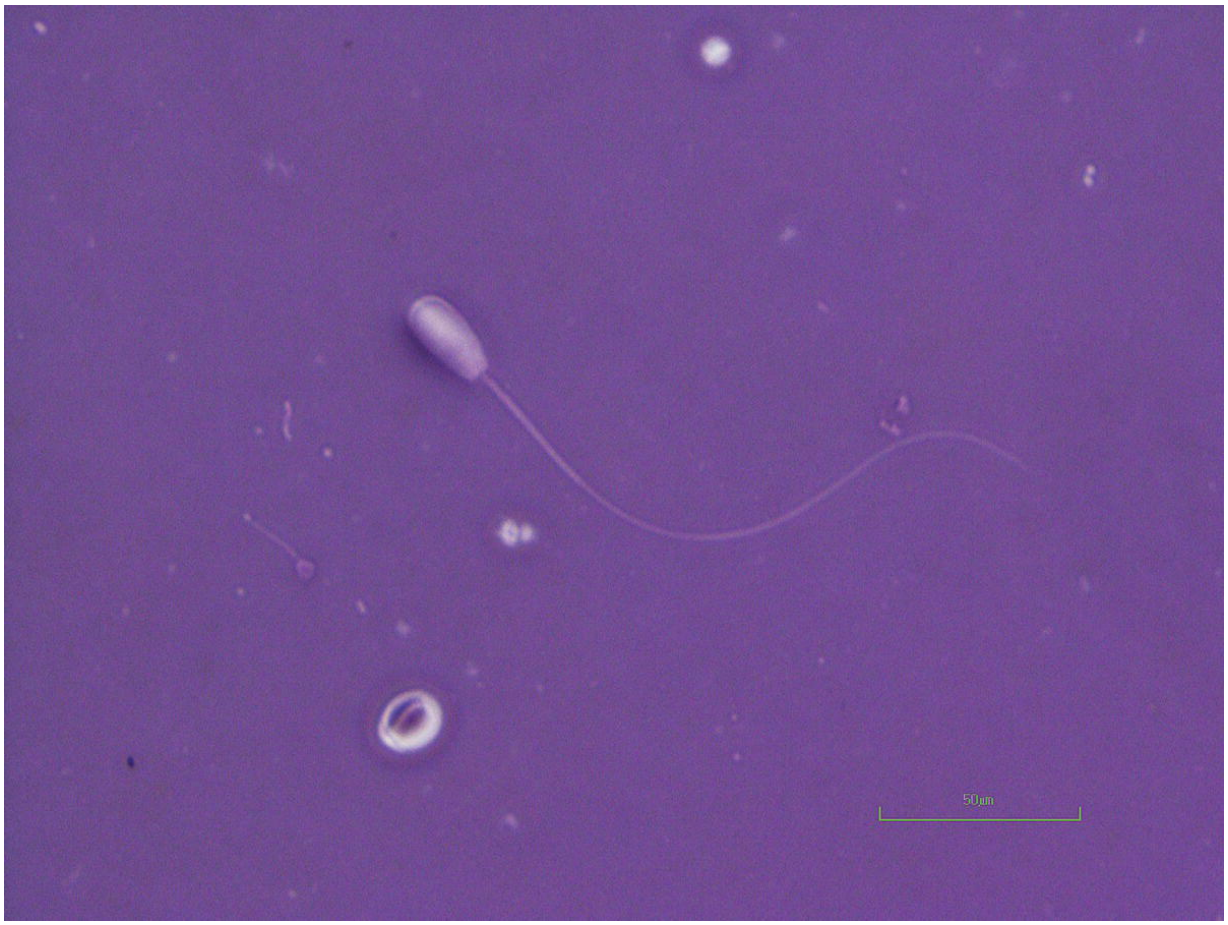

Figure I.1 Morphologically normal sperm from a bull (eosin–nigrosin, 1000×).

Spermatogenesis can be divided into three phases. The first phase, proliferation, consists of six mitotic divisions of spermatogonia, increasing the number of A-spermatogonia then B-spermatogonia. An important part of this phase is stem cell renewal. Loss of intercellular bridges allow some spermatogonia to revert to stem cells. B-spermatogonia then undergo several mitotic divisions, with the last division resulting in primary spermatocytes. The meiotic phase begins with diploid primary spermatocytes. During meiosis I, genetic diversity is ensured by DNA replication and crossing over during production of secondary spermatocytes, and as a result, from a genetic perspective, no two sperm are identical. The last phase, known as the

differentiation phase or spermiogenesis, is differentiation of a spherical undifferentiated spermatid into a fully differentiated sperm with a head, a flagellum which includes the midpiece, and the principal piece. The length of spermiogenesis differs between species. An example is that it takes the last 18 days for the spermiogenesis stage of spermatogenesis to be completed in the bull.

Correct clinical interpretation of spermiograms also requires understanding of the specific timing of spermatogenesis in the species being evaluated. An understanding of the cycle of the seminiferous epithelium aids in this mission. The cycle of seminiferous epithelium is the progression through a complete series of stages at one location along a seminiferous tubule. On cross-sectional evaluation of the seminiferous tubule, four to five concentric layers of germ cells are present with each layer representing a generation. Each cross-section along the length of the seminiferous tubule will have a distinct appearance. Each cross section with its four to five generations of germ cells represents a stage of the seminiferous epithelium cycle. For example, a cross section in stage 1 will have a base layer of A-spermatogonium followed by primary spermatocytes, and another layer of primary spermatocytes, followed by a layer of immature spermatids. A stage 8 cross section will begin with a layer of A-spermatogonium, followed by B-spermatogonium, primary spermatocytes, immature spermatids, and mature spermatids that are ready to be released into the lumen. Along the length of any given seminiferous tubule, there are many zones or cross sections in different stages with only a few zones at an appropriate stage to release mature spermatid into the lumen of the seminiferous tubule, which will then travel through the rete testis to be transported to the head of the epididymis. These different zones allow for the creation of a spermatogenic wave or constant release of

sperm along the length of each tubule. With zones in multiple stages along the length of the tubule, there is a constant flow of spermiation, which allows for a constant flow of sperm to the epididymis.

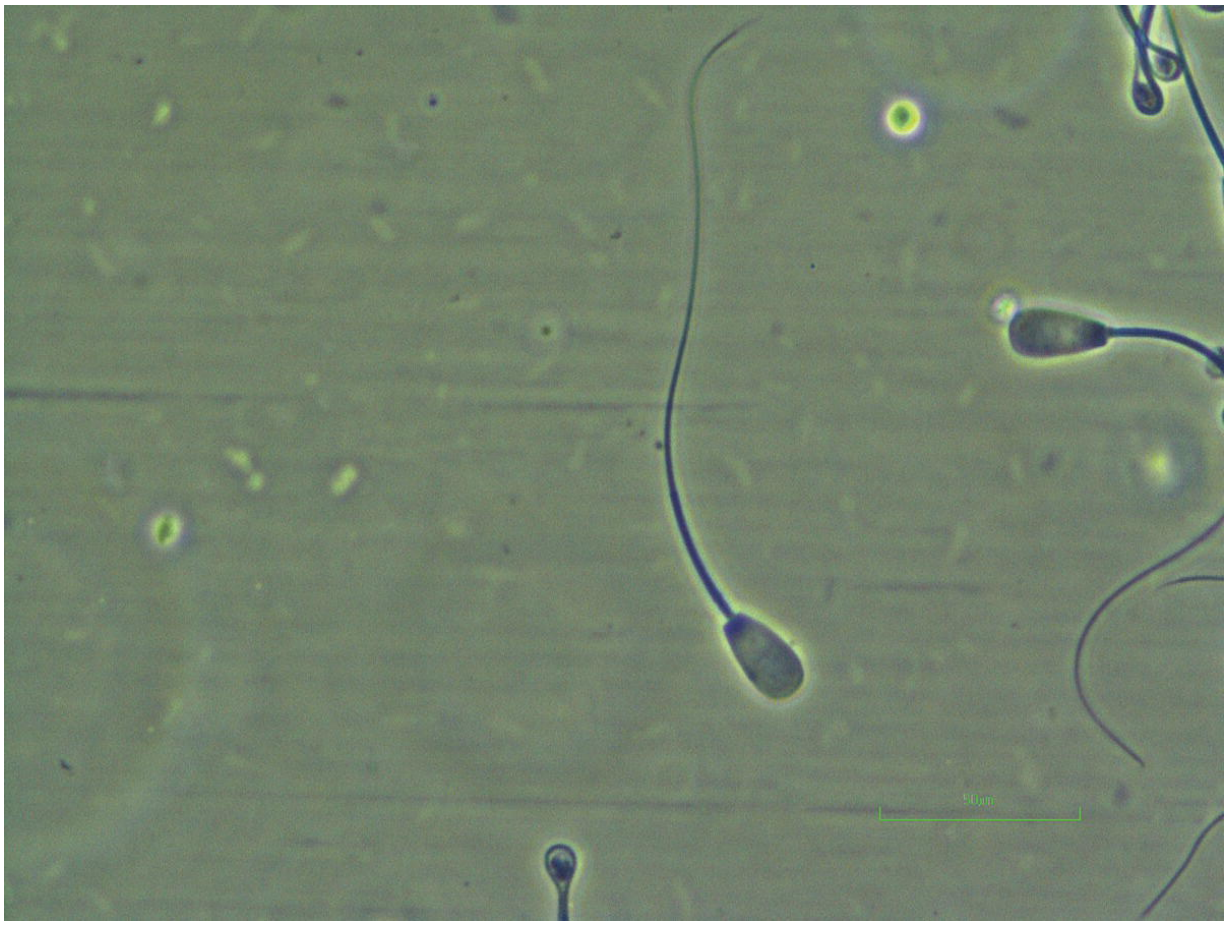

Figure I.2 Morphologically normal sperm from a bull (phase contrast wet mount, 1000×).