The Functions—or Not—of Seminal Plasma?

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In therian and especially eutherian mammals, ejaculate secretions come from a species-variable complex of male accessory sex glands. Accessory gland secretions not only provide the milieu for spermatozoa at ejaculation but also can perform additional defined roles according to species. For instance, components absorbed from seminal plasma can induce ovulation in the camellid species [1, 2] and possibly in the koala too [3]. In some species, much of the ejaculate immediately coagulates to form a vaginal plug. This plug may not be as critical for sperm transport leading to fertilization in hamsters and mice, but in rats it forms a necessary barrier [4] against which, after about 2 min, contractions of the anterior vagina transport the bolus of mostly still-immotile spermatozoa to the fluid-filled uterus [5]. The vaginal plug promotes sperm transport also in the musk shrew and civet cat, but whereas it is removed in the rat by the next coital episode, in species such as the guinea pig the plug acts as a chastity-enforcing device [6]. In many species, however, seminal secretions remain for the most part or entirely as a fluid. In the rabbit, humans, cow, and sheep, as examples, seminal plasma progresses no further than the external cervix, whereas in the pig, dog, and horse, the whole ejaculate passes through the cervix into the uterus. Thus, the fate of male accessory gland secretions can vary widely according to species, and this has been taken into account when considering their possible functions.

The complex of male accessory glands reflects an evolutionary development essentially seen only in mammals, and, as discussed here, their adaptive significance in many species remains uncertain. The constitution of seminal plasma can vary widely also, according to species [7]. In all, it has seemed reasonable to conclude that the function of these glands may initially have related to the benefits of forming a copulatory plug, with the later appearance of different variations reflecting subsequent evolutionary radiations [8]. Possible functions of components in seminal plasma were considered in Mann’s The Biochemistry of Semen [9]. Subsequently, however, the evidence from artificial insemination and from experimental studies of sperm function has suggested that seminal secretions have no critical role per se in the fertilizing ability of spermatozoa. Later, Beer and Billingham [10] suggested that seminal plasma components may help to prevent an immunological response to spermatozoa, but it has yet to be shown whether repeated insemination of epididymal spermatozoa elicits antibodie antibodies. However, in the past two decades, a number of papers have assigned important specific roles for male accessory gland secretions,

Received: 21 October 2014.
First decision: 12 November 2014.
Accepted: 3 December 2014.
© 2015 by the Society for the Study of Reproduction, Inc.
eISSN: 1529-7268 http://www.biolreprod.org
ISSN: 0006-3363

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variously in the transport, survival, and integrity and/or fertilizing ability of spermatozoa and, postfertilization, even in the success of a pregnancy.

These recent studies, which are at odds with many earlier observations based largely on functional end points, are focused to a greater degree at the molecular level. For example, in regard to the influence of seminal secretions on spermatozoa, Ca2+ signaling tools delivered by prostasomes (lipoprotein vesicles secreted by the prostate) have been deemed to be important for activation of mouse sperm motility [11] or in regulation of sperm capacitation [12] and to be fundamental to the success of spermatozoa in fertilization [13]. In humans, likewise, prostasomes are reported to have a role in activation of spermatozoa [14], in enhancement of “sperm capacity” [15], and in the avoidance of premature acrosome reactions [16, 17]. It has been proposed also that human seminal plasma contains proteins important for successful fertilization [18, 19], and a seminal component—soluble tumor necrosis factor-related apoptosis-inducing ligand (TRAIL)—has been reported to promote the survival of human spermatozoa after capacitation [20]. In addition, Bjorndal and Kvist [21] have concluded that the stability of human sperm chromatin depends on the zinc-rich character of the prostatic secretion. On another tack, as judged by the pregnancy rate it appears that epididymal spermatozoa of the sheep negotiate the cervix more successfully when suspended in seminal plasma [22], and it has been proposed that a seminal vesicle component (SVS2) is essential for mouse sperm survival in the uterus [23], though this is not so in sheep [22]. Finally, certain bovine seminal proteins are reported to induce an important cholesterol efflux from epididymal spermatozoa during capacitation [24], while others (oviduct binder sperm proteins) are judged to be a key in establishing the sperm population in the oviduct isthmus [25, 26], from whence a very few potentially fertilizing spermatozoa migrate to the oviduct ampulla.

Not only does this recent literature deem that accessory gland secretions promote sperm fertilizing ability at several specific points in the ascent of spermatozoa, but they are reported to have protective effects also on the sperm genome. A series of studies specific to the hamster (see Poon et al. [27]) have concluded that male accessory gland secretions serve in an antioxidant role and that their absence brought by gland ablation brings a disturbance of epigenetic programming of the sperm nucleus reflected later in the state of golden hamster embryos. A similar outcome in mice [28] has been attributed in part to damage of the sperm genome but also to effects on the female tract. A further role postulated for seminal secretions rests in the concept that absorption of seminal components has a positive impact on implantation and, subsequently, embryo development. This was inferred in comparing a 7% embryo survival in women not recently exposed to seminal plasma with an 11% survival at 6–8 wk in those having intercourse around the period of embryo transfer [29]. Later studies in this vein have concluded that seminal fluid primes the regulatory T cells involved in the interplay between antigens expressed by the