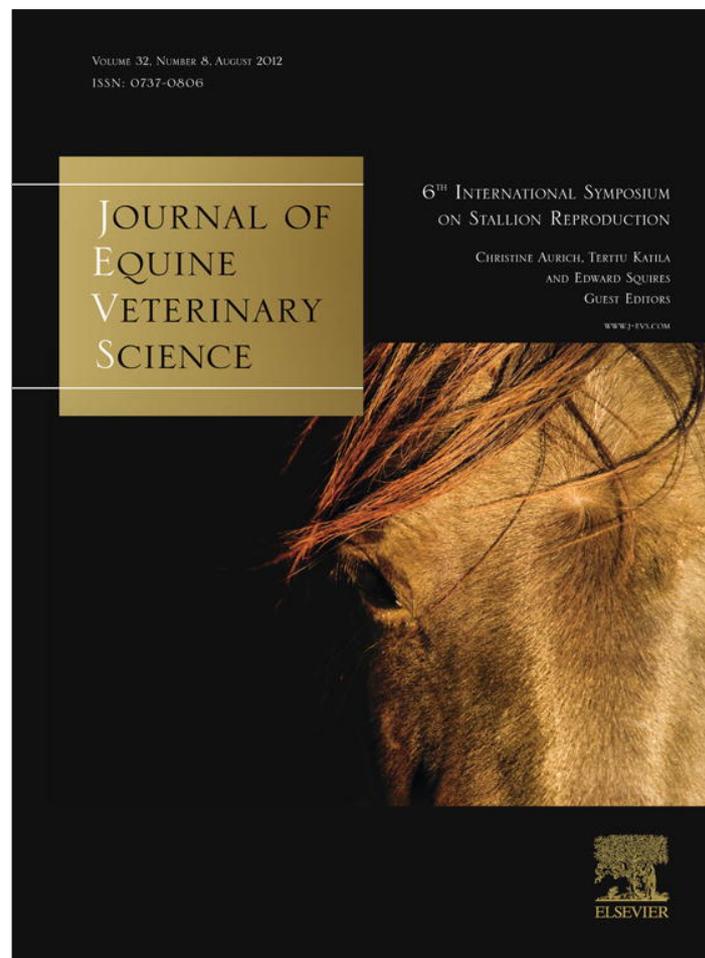


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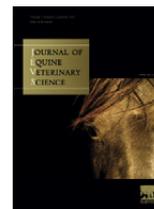
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Review Article

The Potential Effects of Social Interactions on Reproductive Efficiency of Stallions

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ABSTRACT

The reproductive efficiency of stabled domestic stallions is often lower than what could be expected from observations in feral herds. In the wild, stallions typically live with mares in harem bands, with other stallions in bachelor bands, or occasionally in mixed-sex transitional bands. We, therefore, argue that permanent contact with mares may increase reproductive efficiency of stallions suffering from low libido and/or fertility. We also provide a summary of our present knowledge of natural conditions, management, and husbandry of domestic stallions, and of intra- and intersexual behavioral interactions in horses.

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1. Introduction

Numerous ethological studies on feral herds of horses illustrate considerable differences between reproductive behavior and fertility of stallions in the feral herds versus stallions kept under constrained artificial conditions [1,2]. With the increasing predominance of artificial breeding techniques, stallions in many equestrian disciplines are required to take up their stud “duties” while maintaining an active “career” in equestrian sport. Although some stallions seem to cope well with this dual challenge, others experience problems with low libido and fertility. Low libido and fertility are sometimes problems even in stallions used uniquely for breeding. Such animals often have

high genetic and financial values, that is, economic and genetic consequences may contribute to the frustration of owners or managers. Although there are many studies relating reproductive function to endocrinological levels [3,4], interdisciplinary studies examining social and sexual interactions on libido, ejaculates, and sperm quality are scarce.

2. Natural Conditions

Under feral conditions, a certain percentage of mature stallions become harem stallions and maintain a herd of breeding mares, while some remain nonbreeding “bachelors” [5–7]. A harem typically consists of one, occasionally two, harem stallions (one harem stallion and one assistant harem stallion) with a herd of one to nine or more breeding mares together with their predispersal offspring. Observations in free-running equid populations indicate that harem stallions will generally avoid breeding females born within

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their band. However, the mechanisms that lead to this avoidance of inbreeding are not yet fully understood [2].

The harem stallion is primarily a provider of protection and herd cohesion rather than a constant initiator of reproductive interactions. As with other mammals, it is usually the mare that plays the decisive role in mate choice and that initiates copulation [1]. It seems that active harem stallions cover no more than 20 mares in a year, in contrast to managed reproduction, in which each mare is mated approximately six times per cycle [8].

Most stallions without a harem form cohorts known as bachelor stallion bands. These bands are subject to frequent fluctuations in group size and usually consist of 2–17 stallions. A majority of stallions in bachelor bands are 2–5 years old and therefore could be considered too young to be serious contenders for harem stallion status. Older stallions are occasionally members of such bachelor bands because they either were displaced from or could never achieve a harem [9]. Bachelors show no or little breeding activity, but mating is sometimes possible with young mares that have dispersed from a harem band. So-called “transitional bands,” that is, groups of mares without stallions or mixed-sex peer bands of nonbreeding juvenile horses and subadults are sometimes observed [2,10].

3. Management and Husbandry of Domestic Stallions

Modern husbandry and reproductive procedures differ greatly from natural conditions. Reproductive management methods are based on semen collection either through use of a phantom and artificial vagina or through “in hand service.” Stallions are usually kept in individual box stalls and paddocks either fully isolated or with restricted physical contact to other horses. The use of restrictive management practices originates—beside their use in sport and sanitary prescriptions for semen donors—from the desire to reduce the potential for a stallion to injure itself or others (horses or handlers) through the engagement in activity or aggression that could be provoked by the presence of other horses.

In a recent survey of 29 stud farms with purebred Arabian horses in Germany [11], approximately 70% of the 78 stallions were kept without free social contact with other horses. This restrictive and widely practiced form of husbandry leads to varying degrees of limitation in social contact of a physical, visual, olfactory, and auditory nature, depending on the construction and location of a stallion's box. When comparing this with the observation that stallions in a natural environment spend little time in social isolation (3–30%, on average not >8% [9]), it seems likely that social isolation compromises animal welfare [12]. Social isolation may even be a contributing factor to high aggression and undesirable behavior toward other horses [13] and humans [11,14,15] and may eventually lead to self-mutilation [16]. Such behavior frequently requires therapeutic management or the application of pharmaceuticals all with certain pros and cons and varying degrees of success [17].

On multistallion breeding farms, stallions are frequently housed together in stallion barns, intentionally placed outside the range of visual or auditory contact with the barns housing mares. This form of housing can simulate

a form of bachelor herd [18], and it may lead to a suppression of reproductive function. Several studies have reported on the behavioral and physiological parameters of bachelor versus harem stallions, indicating that the bachelor status is associated with lower androgen levels, sexual and aggressive behavior, testicular size, and semen quality [18–20]. The comparatively peaceful nature of such bachelor groups containing sexually mature and immature stallions under semiferal and domestic conditions has been described in several studies [19,21–23].

The number of sexual encounters required of a well-frequented domestic stallion is far higher than that of its feral counterparts popular thoroughbred stallions will cover up to 200 mares in a season [24]. This necessitates the breeding of three to four mares every day without any accompanying social interaction that is typical of an active harem stallion. Additionally, some will cover mares during Northern and Southern Hemisphere seasons [24]. Although stallions that are used predominantly for artificial insemination are slightly less active, high demand for chilled semen requires daily semen harvesting throughout the breeding season. Such a breeding frequency far exceeds “natural” conditions. Considering the average domestic stallion's limited possibilities for normal social interaction, it is perhaps not surprising that libido and fertility problems result. In response to these problems of the equine industry, optimizing stallions' reproductive efficiency has become a research priority.

4. Intra- and Intersexual Interactions and Their Effects

McDonnell and Murray [18] found that harem stallions have significantly higher levels of testosterone than bachelor stallions. In this study, the harem stallion was in constant competition with the bachelor stallions, as all were kept in the same pasture. In other studies, breeding (harem) stallions were kept in a less competitive environment. Aurich et al. [25], for example, observed that breeding stallions have lower plasma testosterone levels than sexually inactive stallions, whereas Khalil et al. [26] found that fecal testosterone levels rose with increasing harem size in 14 feral stallions. We, therefore, suggest that keeping stallions in contact with one or few mares (potentially with regular, but not excessive, sexual activity) may correspond to a “paired” situation associated with low mating effort and low testosterone levels. In comparison, the constant competition experienced by a harem stallion or a domestic stallion stabled together with a large group of other horses could provide a social context that would normally lead to a high mating effort and that constitutes a situation often associated with high testosterone levels [27].

Based on studies by McDonnell [1], recent experiments have focused on integrating natural behavioral patterns into modern housing and management conditions for breeding animals. Preliminary results on the interactions between domestic mares and stallions, attained by studying the influence of permanent stallion contact on estrous behavior and fertility in mares, demonstrate that the permanent presence of a stallion affected sexual behavior and conception rates of mares [28]. During the

course of the latter study, distinct and frequent behavioral interactions between the stallion and individual mares could be observed. These interactions are likely to be influenced by various factors, including the highly polymorphic genes of the major histocompatibility complex (MHC) that have been shown to influence odors and mate preferences in mice [29] and other vertebrates (including humans) [30,31]. Typically, males and females avoid MHC-similar mates. Such mate choice may aim to either directly promote MHC heterozygosity or use the diversity on the MHC as a marker to increase overall heterozygosity in offspring, that is, avoiding inbreeding and/or providing an immunological advantage for the progeny.

First preference trials suggest that mares prefer certain stallions over others and that their preferences depend on the stage of their cycle [32]. With regard to possible MHC effects, a statistically nonsignificant tendency for the estrous mares to select MHC-dissimilar stallions could be observed. Our observations thus far suggest that stallions are less choosy (D. Burger, unpublished observations).

In conclusion, we propose that permanent contact with mares could improve the reproductive efficiency of stallions suffering from low libido and/or fertility. Therefore, our current research focuses on the possible effects of permanent mare–stallion contact on sexual behavior, endocrinological parameters, and semen characteristics.

References

- [1] McDonnell SM. Reproductive behavior of stallions and mares: comparison of free-running and domestic in-hand breeding. *Anim Reprod Sci* 2000;60–61:211–9.
- [2] McDonnell SM. Normal sexual behavior. In: McKinnon AO, Squires EL, Vaala WE, Varner DD, editors. *Equine reproduction*. 2nd ed. West Sussex, UK: Wiley-Blackwell; 2011. p. 1385–95.
- [3] Thompson DL Jr, Pickett BW, Berndtson WE, Voss JL, Nett TM. Reproductive physiology of the stallion. VIII. Artificial photoperiod, collection interval and seminal characteristics, sexual behavior and concentrations of LH and testosterone in serum. *J Anim Sci* 1977;44:656–64.
- [4] Roser JF. Regulation of testicular function in the stallion: an intricate network of endocrine, paracrine and autocrine systems. *Anim Reprod Sci* 2008;107:179–96.
- [5] Klingel H. Social organization and reproduction in equids. *J Reprod Fertil Suppl* 1975;23:7–11.
- [6] Klingel H. Social organization of feral horses. *J Reprod Fertil Suppl* 1982;32:89–95.
- [7] Keiper RR. *The Assateague ponies*. Centreville, MD: Tidewater Publishers; 1985.
- [8] Steinbjörnsson B, Kristjánsson H. Sexual behaviour and fertility in Icelandhorse herds. *Pferdeheilkunde* 1999;15:481–90.
- [9] Berger J. *Wild horses of the Great Basin. Social competition and population size*. Chicago, IL: The University of Chicago Press; 1986.
- [10] Waring GH. *Horse behavior*. 2nd ed. Norwich, NY: William Andrew Publishing; 2003.
- [11] Irrgang N, Gerken M. An investigation of housing conditions, applied management, handling practises and behaviour in purebred Arabian stallions. *Züchtungskunde* 2010;82:292–302.
- [12] Kiley-Worthington M. The behavior of horses in relation to management and training-towards ethologically sound environments. *Equine Vet Sci* 1997;10:62–71.
- [13] Søndergaard E, Halekoh U. Young horses' reactions to humans in relation to handling and social environment. *Appl Anim Behav Sci* 2003;84:265–80.
- [14] Rivera E, Benjamin S, Nielsen B, Shelle J, Zanella AJ. Behavioral and physiological responses of horses to initial training: the comparison between pastured versus stalled horses. *Appl Anim Behav Sci* 2002;78:235–52.
- [15] Søndergaard E, Ladewig J. Group housing exerts a positive effect on the behaviour of young horses during training. *Appl Anim Behav Sci* 2004;87:105–18.
- [16] McDonnell SM. Practical review of self-mutilation in horses. *Anim Reprod Sci* 2008;107:219–28.
- [17] Stout TA. Modulating reproductive activity in stallions: a review. *Anim Reprod Sci* 2005;89:93–103.
- [18] McDonnell SM, Murray SC. Bachelor and harem stallion behavior and endocrinology. *Biol Reprod Mono* 1995;1:577–90.
- [19] McDonnell SM, Haviland JCS. Agonistic ethogram of the equid bachelor band. *Appl Anim Behav Sci* 1995;43:147–8.
- [20] McDonnell SM, Pozor MA. Accessory sex gland size and character differ between harem and bachelor stallions. In: *Proceedings Second International Workshop on Erection and Ejaculation in Horse and Men*. Mount Joy, PA; 1995. p. 43–44.
- [21] Christensen JW, Ladewig J, Søndergaard E, Malmkvist J. Effects of individual versus group stabling on social behaviour in domestic stallions. *Appl Anim Behav Sci* 2002;75:233–48.
- [22] Heitor F, Vicente L. Dominance relationships and patterns of aggression in a bachelor group of Sorraia horses (*Equus caballus*). *J Ethol* 2010;28:35–44.
- [23] Tilson RL, Sweeny KA, Binczik GA, Reindl NJ. Buddies and bullies: social structure of a bachelor group of Przewalski horses. *Appl Anim Behav Sci* 1988;21:169–85.
- [24] Squires EL. Changes in Equine reproduction: have they been good or bad for the horse industry? *J Equine Vet Sci* 2009;29:268–73.
- [25] Aurich C, Gerlach T, Hoppen H-O, Aurich JE. Sexual activity influences the secretion of reproductive hormones in the stallion. *Reprod Domest Anim* 1999;34:405–11.
- [26] Khalil A, Nakahara K, Tokuriki M, Kaseda Y, Murakami N. Variation in fecal testosterone hormone concentration with season and harem size in Misaki feral horses. *J Vet Med Sci* 2009;71:1075–8.
- [27] Ellison PT. *On fertile ground: a natural history of reproduction*. Cambridge, MA: Harvard University Press; 2001.
- [28] Burger D, Trauffler S, Janett F, Bachmann I, Gerber V, Thun R. Influence of a permanent stallion contact on estrus behavior and fertility in mares: preliminary results. 5th International Conference on Equine Reproduction Medicine, Leipzig, Germany, 24–25.11.2007. *Pferdeheilkunde* 2008;24:125 (workshop abstract).
- [29] Yamazaki K, Beauchamp GK. Genetic basis for MHC dependent mate choice. *Adv Genet* 2007;59:130–45.
- [30] Huchard E, Knapp LA, Wang JL, Raymond M, Cowlshaw G. MHC, mate choice and heterozygote advantage in a wild social primate. *Mol Ecol* 2010;19:2545–61.
- [31] Wedekind C, Ewan G. Mate choice, the major histocompatibility complex, and offspring viability. In: Muehlenbein MP, editor. *Human evolutionary biology*. Cambridge, UK: Cambridge University Press; 2010. p. 309–21.
- [32] Burger D, Meuwly C, Marti E, Oberthür M, Sieme H, Lazary S, et al. Investigation on female mate choice in horses and possible association with the MHC. *Anim Reprod Sci* 2010;121:563–4.