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Review Article

Aspects of Breeding Stallion Management with Specific Focus on Animal Welfare

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ABSTRACT

Risk prevention is often counterproductive to stallions' living conditions when assessed under welfare aspects. In the wild, stallions live in social groups, but under domestic conditions, the majority of breeding stallions live in individual boxes with limited social contact. This stimulates aggressiveness and the incidence of stereotypic behavior. While racehorse stallions start their breeding career after having finished their performance career, riding horse stallions are often simultaneously used for breeding and performance. Training, performance, and the associated stress are unlikely to impair semen characteristics, but performing stallions may benefit from more opportunities for social contact. With regard to accommodation of stallions in single boxes, changes in the construction of the partition between them may help to improve social contact from merely visual to much more physical. This will help to reduce social isolation but requires careful observation if neighbors tend to either sympathize or fight with each other. Careful organization of the barn is thus of great importance. Under certain conditions, even keeping adult stallions in groups on spacious pastures is possible. Interestingly, the frequency of agonistic interactions usually decreases quickly and remains low after successful group integration. General changes in the husbandry of young stallions and at their transfer into the future career may help to produce stallions with better social skills and facilitate accommodation under improved welfare conditions.

1. Introduction

Stallions are the focal point of equine breeding programs. They are selected based on either pedigree, performance, conformation, or a combination of these. Individual stallions may become extremely popular with breeders because of their own or their offspring's performance which may result in an over average influence on development of a certain breed. The number of mares bred per season and the breeding fee of some stallions may therefore be extraordinarily high. In conclusion, individual stallions will achieve a high monetary value. This is, however, often a burden to the animal because risk prevention is counterproductive to living conditions of horses when assessed under welfare aspects.

Under wildlife conditions, stallions live in social groups either as a dominant male, i.e., a so-called harem stallion in a group of females and their foals, or in a group of bachelor stallions [1,2]. Thus, stallions spend only a very limited time of the day alone [3]. In contrast, under domestic conditions adult stallions are usually housed in individual box stalls to reduce injuries and - when used as semen donors - also for sanitary reasons [4,5]. Physiological sexual behavior in male individuals – irrespective of species – to a certain extent includes aggressive behavior and may even be associated with unmanageable sexual drive or activity. Handling of stallions can therefore represent a serious safety concern and may complicate animal husbandry considerably [6]. Social interaction of stallions with other horses is therefore often strongly restricted. Contact to mares is usually completely absent or reduced to the time spent in hand for natural mating or semen collection, respectively [7]. The restrictions of social contact in stallions may seriously affect their libido and sexual performance [8,9]. Prevention of both, access to pasture grazing as well contact to conspecifics are prejudicial to the welfare of herbivore and highly social animals like horses [10,11,12]. The increased incidence of aggressive behavior and stereotypies in stallions is suggested a consequence [2,10].

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Confinement stress has been studied in a variety of farm animals, but less attention has been paid to its effects in equids so far [13]. There is therefore a general lack of data on the welfare of breeding horses and only recently, the interest into this research area has increased. This manuscript aims to review the effects of housing and management on behavior, welfare and fertility of breeding stallions. It will also review new approaches to improve stallion accommodation.

2. Short Summary of the Domestication of Horses and the History of Stallion Management

Approximately 5000 years ago, the horse was domesticated [11,14,15]. Initially serving as a source of milk, meat, and leather [16,17] the horse was subsequently transferred to the function of pulling loads, being stronger and faster than a bovine [18]. As time went by, humans realized that they could accommodate horses and use them for support in the day-by-day work [11]. First confinement of horses was achieved in small paddocks with access to pastures; with the evolution of civilization, however, horses were removed from the field and taken to the city where they were increasingly confined in small stables that only allowed restricted movements [19]. While living with humans provided shelter from extreme temperatures, protection against predators and diseases and a reduction in deaths caused by thirst and starvation [11,20], housing in stables was also associated with the development of behavioral problems. This may be associated with the conflict that psychological needs to respond to environmental challenges still exist in domesticated horses even when the biological need to perform adaptive behavioral responses has been removed [21]. Stereotypies do not exist in equids under wildlife conditions but emerge in captivity or under domesticated conditions and put equids under physical and psychological risk [21,22]. They are most abundant in stallions probably as a result of deprivation of space to express their natural behavior [3,20,22].

Written reports on the stabling of horses date back as early as 1400 BCE to a text on chariot horse training written by Kikkuli [23]. Kikkuliś horses were already stabled, rugged, washed down with warm water and fed oats, barley, and hay at least three times per day. Similarly, in the first description of horsemanship by Xenophon around 355 BCE [24], stabling of horses was recommended because it allows for better control of the horse's condition. Although there is no information on housing conditions, the article stresses that "the horse should be housed in a stable where he may be easily checked on by the master. This allows the master to ensure his animal is receiving appropriate care, to prevent his food from being stolen, and to watch to see whether the horse scatters his food." Information on horse care during that time is also depicted from vase paintings [25], but again, there is no detailed information on accommodation of stallions. Both from the vase paintings and from Xenophon's book on horsemanship [24,25], however, it becomes clear that horses, which were apparently male, were kept under rigorous rules: "The groom must also know about putting the muzzle on the horse when he takes him out to be groomed or to the rolling-place. In fact, he must always put the muzzle on when he leads him anywhere without a bridle. For the muzzle prevents him from biting without hampering his breathing; moreover, when it is put on, it goes far towards preventing any propensity to mischief." Xenophon's statement that "vicious horses, when gelded, stop biting and prancing about, to be sure, but are none the less fit for service in war" [25], clearly suggests that handling of geldings was suggested to be easier than that of stallions who tend to show undesired behavior.

In addition to the rigorous confinement of horses in stables and when handled by men, there is clear evidence that performance horses were already fed concentrates in addition to roughage [11,23,26]. Although domestication of horses started late in comparison to other domestic animal species, the equine species was more heavily affected with regard to deprivation from its physiological requirements [2,22]. The luxury and pampering that many valued horses and especially stallions are exposed to may not sufficiently balance for an apparent lack of exercise and social contact they frequently have to suffer.

3. Management of Stallions Today

Keeping stallions stabled and using them for reproduction purposes requires consideration on how the environment and management practices will affect their physical and mental welfare. The use of tie-stalls that was quite common at least in Europe until the 1980s and is still used on large stud farms in Eastern Europe is associated with an increased incidence of health problems especially in stallions. These probably reflect a long-term lack of exercise and standing on wet and soiled bedding [12].

Nowadays, breeding stallions are usually housed in individual boxes together in a barn but separated from mares. This housing system is mostly maintained throughout the year, i.e., independent from the stallions' breeding activity. Among feral horses, breeding is sharply seasonal, e.g., in the Northern hemisphere starts in March and ends in August, with peak activity in May and early June [27]. Breeding activity in the modern horse industry occurs at a similar time of the year but will usually start earlier, i.e., already in January [28]. During the breeding season, active breeding stallions are expected to engage in breeding activities several times a day if in a "natural cover" management system or several times a week if in an artificial insemination program. With natural cover being still the only accepted form of breeding in the Thoroughbred horse, the number of mares covered per stallion and year rarely exceeds 100 in this breed (e.g., in 2019 and 2020, only 14% of stallions in the UK covered more than 100 mares per season [28]). Artificial insemination enables stallions to breed considerably more mares per season without putting the animals under an increased physical strain because the number of semen collections will usually not exceed one per day. Both "artificial" conditions, however, differ considerably from those in feral horse herds where a harem stallion typically interacts continuously with his band of mares. Also, his sexual activity is focussed almost exclusively on mares belonging to his harem which rarely exceeds a number of 10 mares [1,27,29]. Under domestic conditions, although the number of mares bred to the stallion is usually larger, his contact to mares in case of AI is either non-existent or limited to short contact to a teaser mare [30]. In case of natural cover, the stallion will not be allowed any more intense contact to a mare that is often heavily restrained or even sedated and therefore unable to establish any interaction with the stallion except for copulation [31].

It can, however, not be excluded that this restricted interaction is sufficient to modulate hormone concentrations and influence animal welfare because testosterone and cortisol concentrations in stallions vary considerably depending on their socio-sexual conditions: Regular sexual activity i.e., semen collection in stallions reduces concentrations of LH, testosterone and estradiol in plasma [32]. Semen collection itself is not more than a moderate stressor and therefore not leading to major changes in cortisol release and heart rate [30]. Cortisol release in stallions already increased in response to sexual arousal [33,34,35,36,37]. In breeding stallions housed in individual boxes adjacent to each other, cortisol concentration in saliva continuously increased during the breeding season whereas in geldings kept under similar conditions as well as in group-housed young stallions and geldings, salivary cortisol concentration decreased throughout the breeding season [38] (Fig. 1). It is therefore highly likely that the housing of sexually active stallions in adjacent boxes in a barn represents a stress-like challenge.

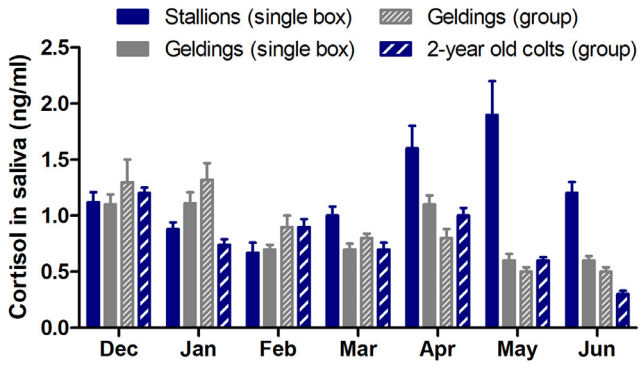

Fig. 1. . Salivary cortisol concentrations from December to May in adult stallions and geldings kept in single boxes and geldings and 2-year old stallions kept in groups. Values are means ± SEM (standard error of the mean). Significant changes over time ($P < 0.001$) and interactions group x time ($P < 0.05$; general linear model; from [38], adapted).

Whereas housing of adult stallions in boxes with visual, auditory, and olfactory contact to their neighbours resembles the situation in bachelor stallions (without contact to mares), regular sexual activity at semen collections is more similar to the situation in harem stallions. This may stimulate some aggressiveness with stallions intending to fight their neighbours and round up their harem [1]. Influences on animal welfare, behavior and also libido and fertility are thus possible. In individual stallions such conditions may suppress libido to an extent that semen collection is no longer possible [8,32].

Racehorse stallions will start their breeding career after having finished their performance career. In contrast, stallions from sport horse breeds like Warmbloods, Iberian horses, Arabians, or American Quarter horses often breed exclusively via artificial insemination and are simultaneously trained and used for performance. This does not only increase their popularity and market value but will also counteract a lack of exercise often seen in stallions used for breeding only [12]. The parallel use of stallions for breeding and equestrian sports requires that training and performance do not negatively affect their fertility. In addition to the actual competition, transport, and exposure to new environments, including other horses, humans and new stables might interfere with reproductive functions [39]. On the other hand, breeding activity stimulates male behavior and can therefore be detrimental to the stallion's handleability and performance. This might convince riders and trainers to ask for medical suppression of male behavior without interfering with fertility, a request that, however, cannot be satisfied: Almost any treatment that reduces male behavior will also interfere with testicular function [6,40], and even if treatments with a "transient" effect are used, long-term influences on stallion fertility cannot be excluded. More importantly, such treatment is not permitted for male performance horses under the regulations of the International Equestrian Federation (Fédération Equestre Internationale; FEI).

There is, however, still the question if training, performance and associated activities like road or air transport to the competition site may interfere with semen quality in stallions. Controlled daily exercise over 16 weeks did not impair semen characteristics in 2-year-old sexually inexperienced Morgan horses [41]. In mature Warmblood stallions, training and competition was not detrimental to semen characteristics although stallions were regularly competing at intermediate and advanced level in dressage or show jumping. In these animals, plasma cortisol concentration was not different from stallions not competing but regularly used for breeding [39]. When more recently, effects of exercise on semen characteristics were determined in Criollo stallions, only minor detrimental effects were detected, and semen characteristics always remained within a physiological range [42]. In pigs, sheep and cattle, stress effects on gonadal function are mainly exerted via increased cortisol secretion [reviewed by 43]. Training of horses will always cause a transient increase in cortisol concentration as will transport [44,45,46]. When the hypothesis that increased cortisol concentration impairs testicular functions was tested in Shetland stallions, there was neither a detectable negative effect of long-distance transport nor of pharmacologically increased cortisol concentrations on semen characteristics and testosterone secretion [47]. Testicular function in stallions is thus well protected against transiently elevated cortisol concentrations. This assumption is further supported by the detection of active 11β-hydroxysteroid dehydrogenase (11βHSD) type 1 and its oxidative activity (i.e., conversion of active cortisol into inactive cortisone) in equine epididymal and testicular tissue [48]. Intensive exercise of stallions may, however, increase their body core temperature. If exercise is performed on a treadmill or stallions are equipped with testicular suspensories, scrotal surface temperature increases and may interfere with semen characteristics [49]. Ambient undisturbed airflow is enough to prevent such effects even in the presence of extreme heat and humidity [49,50,51].

The present results allow for the conclusion that exercise and performance are thus unlikely to impair semen characteristics in stallions. On the contrary, they may contribute to improvement of animal well-being by providing exercise and social contact to the stallion. This does, however, not exclude that individual stallions may not be able to cope with the combination of breeding and performance. In such cases, the production of frozen semen may help to allow such stallions concentrating exclusively on their performance while they can still produce offspring.

4. Behavioral Problems in Stallions

Stereotypies in animals are induced by restricted environments, suboptimal housing conditions or management problems [21,52], i.e., they derive from stressful or frustrating environments [52,53]. They occur exclusively in captivity whereas equids under wildlife conditions will usually not show any stereotypic behavior. Therefore, behavior problems are a major concern in zoo equids. Stereotypies most occur in solitary male individuals in the form of pacing. Turning the male out on a larger pasture that allows for grazing will reduce pacing, but it does not completely cease [3]. In this context, it is interesting to note that also environmental enrichment (e.g., the presence of a window allowing the horse to observe the environment) or improvement of management practices (e.g., increasing the time spent being ridden) could not alleviate the negative effects of housing in individual boxes on equine welfare [22]. Providing companions to solitary equids is by far more effective in this regard [3].

In stallions, stereotypies are more frequently displayed than in mares and geldings. This together with an increased incidence of aggressive behavior is considered a consequence of their limited social contact [2,10]. Interestingly, the risk of stallions to display stereotypic behavior increased when breeding activity was combined with performance training [54]. Differences in management, however, only partially explain differences in repetitive behavior among sexes in horses: while weaving was more common in stallions than in mares or geldings, crib-biting occurred more frequently in male than in female horses but irrespective of their gonadal intactness [53]. There is clear evidence for differences in behavior between male and female horses already before puberty [55,56,57]. Male horses are usually more active than females as has also been described in adult Przewalski horses [3]. This trait may also contribute to the increased development of stereotypic behavior in males. In this context, it has to be considered that

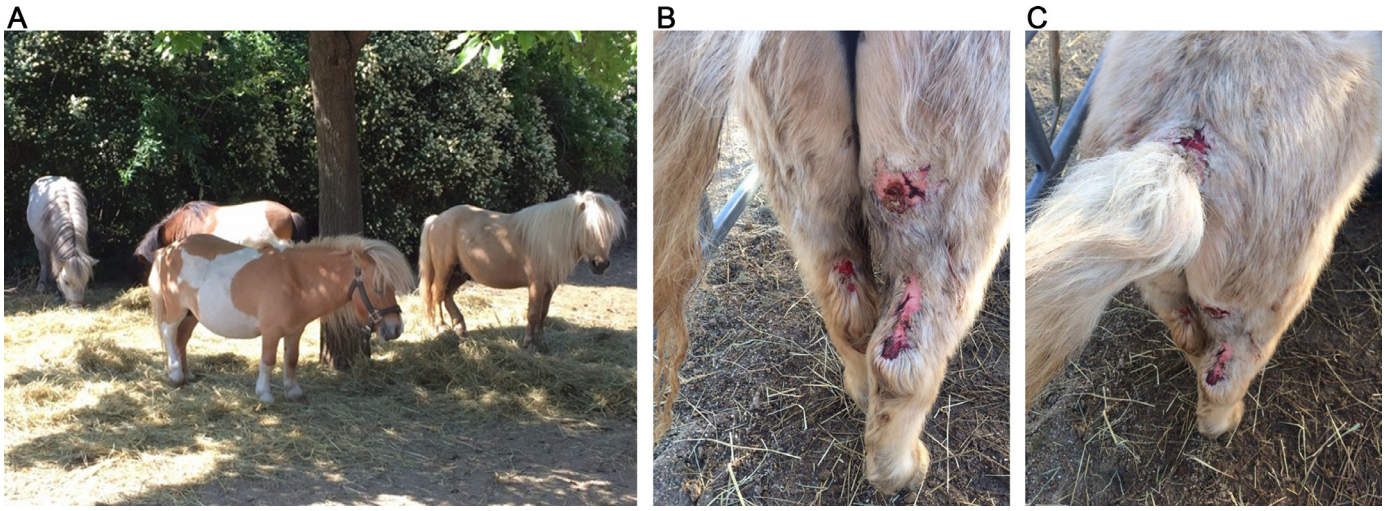

Fig. 2. . (A) Adult Shetland research stallions of the Vienna Centre for Artificial Insemination regularly used for semen collection and kept in a bachelor group and (B,C) the paint stallion in the front after suffering biting injuries from one of his group mates in the following winter season.

Fig. 3. . Warmblood colts at two years of age without any sexual experience kept in a group on pasture.

stallions kept in single boxes with at best limited access to pasture will receive less forage and more concentrate than broodmares kept in group stables or on pasture. The feeding of high energy, low-fiber concentrated feeds without access to high-fiber forage is associated with a higher incidence of stereotypic activities in both epidemiological [58] and experimental studies [59,60] and may thus at least partly explain a higher incidence of stereotypies in stallions.

When fertility was determined in mares displaying stereotypic behavior, lower conception rates than in normal mares were detected despite the occurrence of regular estrous cycles [61]. The study was performed at a breeding facility in Tunisia where mares were managed transiently for breeding until pregnant. It is well possible that both, stereotypic behavior and impaired fertility are a consequence of inadequate management conditions at the mares' home but there is not necessarily a causal relationship. It has been suggested that engaging in stereotypic behavior is a strategy to prevent stress because the display of stereotypic behavior, such as crib-biting reduced endogenous cortisol release irrespective of sex [62]. Stereotypic behavior might therefore even prevent detrimental effects on fertility of inappropriately managed breeding horses. To the best of our knowledge, there is so far no information on any association between the display of stereotypies and fertility in stallions.

5. Alternative Housing forms and Solutions to Improve the Welfare of Stallions

The greatest problem about the wellbeing of breeding stallions is their lack of direct social interaction with conspecifics. It must therefore be the aim to allow stallions more social contact without endangering their health and fertility. This is, however, not an easy task. Nowadays on breeding farms with several stallions, they 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 may simulate living in a bachelor herd. Nevertheless, the lack of full-scale physical contact among neighbours in singly stabled stallions does not allow for the formation of associative relationship described in horses living in groups [4]. In contrast, in old fashioned tie-stalls used for accommodation of stallions on large stud farms outside the breeding season in former times, the opportunity of an increased social contact may explain a low incidence of stereotypies [12,63,64]. This advantage is, however, clearly counteracted by the lack of opportunity for free movement and exercise resulting in considerable health problems [12] and tie-stalls are no longer accepted in many countries.

In singly stabled horses, the opportunity of close visual and tactile contact with the neighbouring horse through a grille in the partition reduced stereotypic behavior [65] and may thus be beneficial also for the accommodation of stallions. This system was recently further extended by introduction of a so-called “social box” [66,67]. Part of the partition between 2 adjacent boxes is replaced by several strong vertical metal bars at 30cm-intervals (Fig. 4). Stallions can thus put their head, neck and 1 or the other forelimb through the spaces between bars and get in direct tactile contact with each other. The remaining part of the partition is solid and thus allows for privacy. This system has recently been introduced into the stallion barn of a German sport horse stud farm. Aggressive behavior was limited to the first hours after housing the stallions in the barn [67]. Minor head injuries occurred but may be minimized by using alternative construction material for the vertical bars [66].

The fact that under wildlife conditions, stallions will almost always live in social groups is unknown to many horse enthusiasts. The picture of fighting stallions bringing each other close to death has been kept alive for centuries by numerous books and movies. Actually, at their first encounter, unfamiliar stallions will display pronounced aggressive behavior that discourages the majority of owners and breeders from keeping adult stallions in groups. With the aim to reconsider the situation, the possibility of housing adult breeding stallions in groups on spacious pastures far off mares and other horses was investigated [68]. Among the Franches-Montagne stallions (a Swiss draft horse breed), the frequency of agonistic interactions decreased quickly and remained low already four days after group integration. Ritual behavior occurred much more frequently than agonistic and affiliative interactions [68]. In Austria, it has become a recent tradition that at the end of the breeding season, breeding sires of the Noriker draft horse breed are allowed to spend some weeks in groups on spacious separated mountain pastures. The day of integration of the stallions into the groups is visited by many spectators watching the impressive ritual fights among stallions, but apparently no greater injuries occur. There are more examples (Fig. 2A) illustrating that group housing of mature breeding stallions is possible. Nevertheless, many owners of valuable stallions will still resist following this idea because in such animals, even minor injuries may cause considerable financial loss. If stallions are able to have physical contact among each other, they may attack and injure their neighbours or group mates, especially when in contact with mares [12, Fig. 2B). Fortunately, major wounds and injuries are not often experienced. optimizing the environmental conditions of a stallion barn with increased physical contact may help to avoid such problems. It may also be of utmost importance to decide if stallions housed in adjacent boxes tend to sympathize or fight with each other and thus reorganize the barn taking this into account. On the other hand, social stabling of stallions will also require stability of the group and will thus not benefit from continuous changes in the group composition.

Fig. 4. . Image of the partition of the “social box” where part of the partition between 2 adjacent boxes is replaced by strong vertical metal bars at 30 cm-intervals. The two spaces allow horses to get in direct tactile contact with each other (copyright of image: Agroscope, Swiss national stud farm).

Young stallions are usually reared in groups (Fig. 3) but will be separated and transferred into single boxes often with no more direct contact to their previous group mates at an age of 2 years. Social deprivation of young stallions for a period of nine months resulted in remarkable long-term differences with regard to their social behavior in comparison to stallions of the same age that were continuously kept in small groups [4]. This suggests that the sudden isolation of young stallions from their group mates at the beginning of training is worth reconsidering. Keeping them in contact to preferred group mates at least for several hours per day, i.e., when turned out into pasture or a spacious paddock may be an option to avoid immediate complete social deprivation and the loss of social skills. General changes in the husbandry of young stallions and at their transfer into the performance and/or breeding career may help to produce stallions with better social skills.

6. Conclusions

Although under wildlife conditions mature stallions live in social groups, there is usually a considerable reduction of their social interaction to other horses under domestic conditions. This is a welfare issue clearly reflected in an increased incidence of behav-

ioral problems in adult stallions. A change and reconsideration of long-term traditions in stallion accommodation is thus necessary. Because horses housed with conspecifics are less prone to develop abnormal behavior, there has to be a continuous and increasing effort to provide adult stallions with opportunities of closer physical contact to their conspecifics.

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