Pferdeheilkunde 26 (2010) 1 (Januar/Februar) 6-9

Factors affecting reproductive performance of horses

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Summary

This paper reviews factors affecting the reproductive efficiency of the mares and stallions. The foaling rates have improved during the decades thanks to the ultrasonography, the new exogenous hormones and the increased knowledge of the reproductive physiology and pathology. In many breeds, the use of the artificial insemination has contributed to the improved pregnancy rates. However, the best reproductive performance has been reported in UK for the Thoroughbred industry where only natural mating is allowed. On the other hand, the use of frozen semen and transported cooled semen has increased lately and results in much lower foaling rates than on-site insemination. This may be an explanation for the decreasing trend in foaling rates discovered in Scandinavia. Horse breeds seem to have different kind of fertility, but this may be related more to the professionalism in the management than to the inherent differences in fertility. The age has much less effect on the stallions' fertility than on the mares' fertility. In mares, a high age is probably the most important factor for decreased fertility. Also the reproductive history exerts an effect: the foaled mares are highly fertile, whereas the barren mares are less fertile. The young maiden mares conceive easily but the old maiden mares are the most problematic group. The matings early in season result in higher pregnancy rates than late season. However, in late season the mare population is different, since only repeat breeders are left for mating. High environmental temperatures may have adverse effects on fertility. During racing, the body temperature raises leading early embryonic deaths in pregnant mares. In stallions, the testicular temperature may increase disturbing spermatogenesis.

Keywords: mare, reproduction, stallion, fertility, age, mating, temperature, racing

Faktoren, die den Reproduktionserfolg beim Pferd beeinflussen

Der Artikel gibt eine Übersicht über Faktoren, die die reproduktive Effizienz bei Stuten und Hengsten beeinflussen. Während der letzten Jahrzehnte wurden die Abfohlergebnisse durch den Einsatz der Ultrasonographie, neuer exogener Hormone und dem ansteigenden Wissen der Reproduktionsphysiologie und -pathologie verbessert. In vielen Zuchten hat zudem die instrumentelle Samenübertragung dazu beigetragen. Demgegenüber werden die besten Abfohlraten in der Vollblutindustrie in Großbritannien erzielt, wo ausschließlich der Natursprung erlaubt ist. Andererseits werden immer mehr Tiefgefriersperma und Transportsysteme mit gekühltem Sperma genutzt, die zu erheblich schlechteren Abfohlergebnissen führen als die Insemination vor Ort. Dies mag eine Erklärung für den beobachteten rückläufigen Trend der Abfohlraten in Skandinavien sein. Pferderassen scheinen unterschiedliche fruchtbar zu sein, der Grund dafür liegt aber eher in der Professionalität des Managements als in einem inhärentem Unterschied in der Fertilität. Der Einfluss des Lebensalters auf die Fruchtbarkeit ist beim Hengst viel geringer als bei der Stute. Bei der Stute spielt das Alter möglicherweise die größte Rolle für eine herabgesetzte Fruchtbarkeit. Auch der Reproduktionsstatus hat einen Effekt: Stuten mit Fohlen bei Fuß sind fertiler als güste Stuten. Junge Maidenstuten konzipieren leicht, während alte Maidenstuten zu den Problemstuten gehören. Die Belegung in der frühen Zuchtsaison führt zu höheren Trächtigkeitsraten als in der späten Saison. Jedoch ist die Population der Stuten, die in der späten Zuchtsaison gedeckt werden, eine andere, da dann nur noch Stuten gedeckt werden, die umgerosst haben. Hohe Außentemperaturen scheinen einen ungünstigen Effekt auf die Fruchtbarkeit zu haben Die während des Rennens ansteigende Körpertemperatur führt zum frühen embryonalen Tod bei der Stute. Beim Hengst kann eine ansteigende testikuläre Temperatur die Spermatogenese stören.

Schlüsselwörter: Stute, Hengst, Fertilität, Alter, Bedeckung, Temperatur, Rennen

Introduction

Epidemiological studies on equine reproduction are scarce; only one large French study comprising several breeds (*Langlois* and *Blouin* 2004) and a retrospective German analysis covering 158 years of breeding statistics on the Hannoverian horses (*Merkt* et al. 1979) have been published. The Thoroughbreds (TB) have been studied much more than the other breeds: mating records of the individual TB farms have been reported since decades (*Laing* and *Leech* 1975, *Osborne* 1975, *Sullivan* et al. 1975, *Brück* et al. 1993, *Hearn* et al. 1993, *Hemberg* et al. 2004), a survey including 22 TB farms (*Morris* and *Allen* 2002), and a study on the entire TB population registered with the Jockey Club in 1987-8 (*McDowell* and *Powell* 1992). Reports have been published also concerning the pasture bred horses (*Hugason* et al. 1985, *Bristol* 1987, *Davies Morel* and *Gunnarson* 2000), feral horses (*Keiper* and *Houpt* 1984), and different horse breeds in USA (*Hutton* and *Meacham* 1968) and in Finland (*Katila* 2003). Nowadays many stud books maintain registers and websites where the breeding data are reported and annually updated. In Finland, Suomen Hippos keeps all horse, studbook and mating registers, which are partly available on their website.

It is often argued that the horses would have lower reproductive efficiency than the cattle, because the horse breeding industry reluctantly culls barren mares, and the stallions are not tested or approved for fertility. This is not true. The sixty-day non-return rates of the high-yielding dairy cows are usually around 60%, but if the pregnancy rates per cycle are

available, they typically range between 30-40%. In horses this would be unacceptably low, with the exception of the frozen semen.

The interpretation of the equine fertility data is problematic, because the first cycle pregnancy rates or the pregnancy rates per cycle and the number of cycles per pregnancy or the number of matings per cycle are usually not available. The seasonal pregnancy rate is not a good measure of the reproductive efficiency, because relatively high seasonal pregnancy rates can be achieved with multiple matings in several cycles. Although the foaling rate reflects the final productivity and is economically the most important one, it has limitations, e.g. mares can die, not all mares bred are reported and not all foals are registered. If we know the seasonal pregnancy rate and the foaling rate, we can calculate the pregnancy loss rate, which is also an important piece of information.

Development of reproductive efficiency

The development in pregnancy rates over time has been totally different when comparing the horses and high-yielding dairy cows. In the cattle, fertility has decreased over the years because of the increased milk production, but in the horses, the pregnancy rates have increased during the last decades. One of the reasons has been the spread of the artificial insemination (AI), but a marked improvement has also been observed in the TB breeding (*Morris* and *Allen* 2002) where AI is not allowed. The use of the ultrasonography has to be credited for much of the improvement, but we should not forget the advancements in the hormonal therapy and our increased knowledge of the equine reproductive physiology and pathology. During the recent years, however, a trend towards the overall decline of the foaling rates has been observed in Finland (*Sairanen* et al. 2008).

A retrospective analysis of the reproductive data of the Hannoverian horses (*Merkt* et al. 1979) covering 158 years (1815-1973) showed amazingly consistent results, e.g. exactly the same foaling rate of 54.3% was reported in 1821-30 and 150 years later. Higher pregnancy and foaling rates, but also more variation seems to be characteristic for the TB horses. During the 1950's and 1960's, foaling rates between 51 and 66% were reported (*Hutton* and *Meacham* 1968, *Osborne* 1975); in addition, a first cycle pregnancy rate of 43% and a seasonal pregnancy rate of 75% were reported in 1967-70 in USA (*Sullivan* et al. 1975). In 1970's the results were similar: the seasonal pregnancy rates varied from 63 to 72% and the foaling rates from 51 to 70% (*Laing* and *Leech* 1975, *Osborne* 1975, *von Lepel* 1975, *Ricketts* and *Young* 1990). In 1980's the results improved: the seasonal pregnancy rates ranged from 72 to 89% and the foaling rates from 66 to 77% (*Ricketts* and *Young* 1990, *Brück* 1993, *Morris* and *Allen* 2002). In 1990's a further improvement took place: a seasonal pregnancy rate of 92% and a foaling rate of 83% was achieved in 1997-2001 in Sweden (*Hemberg* et al. 2004), and respectively, 95% and 83% in U.K. in 1998 (*Morris* and *Allen* 2002).

In France, the improvement in the odds of the foaling rates from 1989 to 1999 was 4%/year for cold-blooded horses which had the lowest foaling rates (51% as calculated from their data) indicating a 1% annual increase in the actual foaling rate (as calculated from their data); the progress of TBs was <1% and the foaling rate 54% (*Langlois* and *Blouin* 2004). In Finland, the foaling rates increased considerably in 1980's because of the start of the AI and ultrasonography, remained very much the same in 1990's and then started to decline. When the foaling rates of the two trotter breeds in Finland, the Standardbred (SB) and the Finnhorse (FH) were analyzed from 1991 to 2005, the foaling rates of FH had decreased from 66% in 1991 to 61% in 2005, and the corresponding figures for the SB were 75% and 66% (*Sairanen* et al. 2008).

Effect of breed and inbreeding

In the early studies, the Quarter horses used to show higher pregnancy and foaling rates than the TBs (*Hutton* and *Meecham* 1968, *Sullivan* et al. 1975), but at the moment, the TBs have higher pregnancy and foaling rates than the other breeds. The cold-blooded horses, Breton, Comtois, Ardenne. Percheron, and Boulonnais in France have lower foaling rates than the warm-blood or TB mares (*Langlois* and *Blouin* 2004), and in Finland the FH consistently show lower foaling rates than the SB (*Sairanen* et al. 2008). It is unclear, whether or not the horse breeds would have different intrinsic fertility. Inbreeding decreases semen quality (*van Eldik* et al. 2006) and fertility and could therefore provide some explanation for the breed differences. The inbreeding coefficients are higher in some breeds than in others, e.g. the average inbreeding levels in Finland were 9% for the SB stallions and only 2.9% for the FH stallions (*Sairanen* et al. 2008), but on the other hand, the foaling rates of the SBs are higher than of the FHs. Differences in semen quality have been demonstrated between the stallions of the different breeds (*Dowsett* and *Knott* 1996) but the effect on fertility is not so clear.

Official records involve various types or errors, e.g. in the declaration of the matings and in the registration of the foals, the practices of which vary between the studbooks. The excellent results achieved in the TB breeding may be related to the high value of the breeding stock which allows the use of the required control and care by the veterinarians and the professionalism of the stud farms. The cold-blood breeding tends to be conservative and the management of the stallions and mares may not be as professional. The size of the stallion's book had a positive correlation with the foaling rates showing the effect of the increasing financial investments and professionalism (*McDowell* et al. 1992), but on the other hand, a large book of >80 mares using in hand mating decreased foaling rates (*Merkt* et al. 1979). The age distribution of the mare population is also different between the breeds. The warm-blooded riding horses can be 10 years older than their TB colleagues when they retire from the races/shows.

Effect of mating type

The pasture breeding results in high foaling rates (*Hugason* et al. 1985, *Bristol* 1987), if the food supply is adequate (*Keiper* and *Houpt* 1984). The foaling rates after in hand mating are lower than in the pasture breeding or AI (*Langlois* and *Blouin*

2004), but for the TBs, in which the in hand mating is the only breeding method, the results are better than in the breeds where AI is used. The on site AI (the mares and the stallion are in the same stud farm) results in higher foaling rates than the in hand mating, cooled shipped semen AI or frozen semen AI (*Langlois* and *Blouin* 2004). The same result was obtained also in the Finnish study (*Sairanen* et al. 2008).

AI with cooled shipped semen has become the most popular mating type in many countries and in many horse breeds; semen is shipped also between the countries, even between the continents. However, not all stallions are suitable for this technique, and semen of the subfertile stallions should not be used at all. The quality and fertility of the stored semen are lower than those of the fresh semen, but there is large variation depending on the stallion, transport time and semen handling techniques. The above mentioned holds true also for frozen semen, even more so. Although satisfactory seasonal pregnancy rates can be achieved with frozen semen, the pregnancy rates per cycle are lower than with the other types of AI. For the frozen semen AI, not only the stallions, but also the mares should be selected to achieve satisfactory pregnancy rates (*Barbacini* et al. 1999).

Effect of age

Very young stallions and mares are not as fertile as adults, but their use in the breeding is limited. The reproductive efficiency of the stallions and mares decreases with aging. The stallions appear to mature later than the mares and age later and slower (*Langlois* and *Blouin* 2004). Although the stallions start to show signs of aging around 15 years of age, more apparent effects on fertility are seen first after 20-25 years of age. The age, when the mare fertility starts to decrease, varies from 10 to 15 years in different publications (*Hutton* and *Meacham* 1968, *Laing* and *Leech* 1975, *Hearn* et al. 1993, *Morris* and *Allen* 2002, *Hemberg* et al. 2004, *Langlois* and *Blouin* 2004) also the risk for the pregnancy loss increases at a similar age. The decreasing pregnancy rates and increasing pregnancy loss rates lead to low foaling rates. The mare age is probably the most apparent single factor affecting the reproductive efficiency of the horses), Whereas the stallions maintain their breeding capacity up to 20 years of age, and sometimes even longer, fertility of the mares >15 years of age is decreased. The riding horse mares tend to be at a too high age when they start their breeding career.

Effect of reproductive history

On the basis of the reproductive history, the mares are classified into four types: maiden (never mated), foaling or foaled (foaled during the same year/breeding season), barren [mated but not conceived during the previous year(s)], and rested [foaled earlier but was not mated again previous year(s)]. Sometimes the aborted mares have been classified separately, but if not, then they are considered to be barren. In some other studies, the rested mares have not been separated.

The maiden mares are considered to be fertile, but sometimes the mares newly retired from the racing can experience difficulties. On the other hand, the old maiden mares (>12 years) are the most difficult group to get in foal, particularly when using frozen semen (*Samper* et al. 2002). The old maiden mares are common in the warm bloods, but rare in the TB and SB populations. The foaling mares are the most fertile mare type, with the exception of the foal heat. The foal heat pregnancy rates are lower and the pregnancy loss rates higher than in the subsequent cycles (*Chevalier-Clément* 1989; *Morris* and *Allen* 2002). The aborted and barren mares tend to have the lowest foaling rates, particularly if frozen semen is used (*Metcalf* 1995, *Barbacini* et al. 1999).

Effects of month, environmental temperature and racing

Matings early in season result in higher pregnancy rates than in late season (*Katila* 2003, *Langlois* and *Blouin* 2004). At the end of the season, only the repeat breeders are left, which may provide an explanation for this difference (*Katila* 2003). Early mating gives the mare more opportunities to conceive and is therefore recommended by *Langlois* and *Blouin* (2004). It is well known that the lengthening of the day induces cyclicity in the mares, but also the nutritional status and environmental temperature may be modifying factors. The effect of the environmental temperature on the foaling rates was analyzed in a Finnish study. Increase in the temperature lowered the foaling rates, although the weather in Finland is never hot (*Pärssinen* 2008). Perhaps this was related to more problem mares being mated in the late summer. The high body temperatures may cause embryonic deaths in the mares similarly to the cows. In the racing and showing mares, the body temperature may be transiently very high (*Mortensen* 2006). In the stallions, the competitions and races in the hot weather, and particularly, if the testis suspensories are used, can increase the testicular temperature and disturb the spermatogenesis (*Staempfli* et al. 2006). Stress induced by the physical activity and shows can alter the hormonal levels and influence the semen quality (*Janett* et al. 2006).

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