A report exploring the extent in which modern stud managers can promote fertility and health in the domestic breeding situation, by learning from the feral horse.

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Introduction

This report will review the social aspects of the feral horse's breeding behaviour and the endocrine systems involved. Whilst highlighting areas that contradict with the general management practices currently employed by stud farms; which may as a result lead to a decreased fertility rate as live foal rates in domestic systems are believed to be 35% lower than pasture bred mares (Bristol : 1987).

The 'preservation of favourable individual differences and variations, and the destruction of those which are injurious' (Darwin : 1859) formed the basis of Darwin's natural selection theory. The feral horse has developed a strategy for the continuation of the strongest and fittest of its species, by adopting the lowest risk of injury or complication, whilst providing the greatest chance of conception and parturition. The feral herd will naturally attempt to reduce inbreeding as 'excessive genetic proximity can produce biologically or psychologically (or both) non-viable progeny' (Beck : 2009).

Robert Bakewell developed a line breeding strategy with livestock to select and breed from the animals with the most desirable traits. 'By in-breeding he established the new Leicestershire breed of sheep, an early maturing animal with a favourable ration of bone to meat' (Bonham-Carter : 1973). A similar line breeding process has occurred in regards to performance in the thoroughbred, with over 80% of the gene pool derived from 31 known ancestors (Gaffney and Cunningham: 1988).

The domesticated horse has its reproduction and fertility controlled to enable specific matings to occur. 'The objectives of man include financial returns and these are based on the fashions of genetic inheritance' (Rossdale : 2003) without regard being given to factors such as conformation or the avoidance of inbreeding. The key determinate for the selection of mating will be the perceived performance and ability of the sire and dam; however this can be influenced by the marketing of studs and the perceived favourability among breeders for particular stallions. Thus, the genetic pool is artificially restricted by this selectivity and furthers the likelihood of inbreeding occurring.

Harem Structure and Dominance Hierarchy

Within the feral horse population two social structures exist, the less common structure is a territorial system, where the available resources are limited and unable to sustain a herd of animals, such as the Shackleford Banks in North Carolina (Rubenstein : 1981). The stallion will guard a particular resource allowing mares and their offspring to move freely. Once a mare enters oestrus,

she will select a stallion for mating, before moving off again post coitus. This freedom of movement and choice of mating partner will help to reduce the chances of inbreeding. However, mares that shift between herds were shown to have reduced reproductive success (Berger : 1983).

The more common harem structure consists of about 7 to 8 mares (Rollin and Kesel : 1995), their offspring and a single mature stallion. A harem group roam within a 'home range' within which will often be a core area, concentrated around a key resource. This key resource will depend on the natural environment; in an arid region water will form the core area, whereas in a colder region shelter will be the main consideration. The core area will be defended by the harem; however the home range may be shared with other harem groups. The size of the harem is generally restricted to around 20 animals; influenced by 'foaling rates and foal mortality, the age of the stallion, the adult sex ratio, and the quality and quantity of food' (Mills and McDonnell : 2005).

A dominance hierarchy exists whenever two or more animals are gathered together (Houpt : 1991), resulting in stronger animals having priority access to food, resources and matings. This should ensure the survival of the fittest and therefore gain the continuation of the species. The existence of the hierarchy within a herd also reduces the level of aggression, risk of injury and energy wastage. It has been found that the stallion is not always the most dominant member of the herd (Houpt and Keiper : 1982, Berger : 1977), a study by Heitor, Oom and Vicente (2006) found rank was positively correlated with age (r_s=0.774, n=10, P<0.05), however a low value of n was used and does not fully prove this theory.

'Offspring of both sexes disperse from natal bands when sexual maturity is attained' (Heitor and Vicente : 2007). This is to prevent inbreeding either by the stallion with his female offspring or by the colt with his family group. For colts this ejection occurs at 18 months, at which point 'bachelor males often form small... assemblages of usually four or fewer members' (Waring : 2002). Colts remain within bachelor groups until they reach an age of between four and six, at which point they seek to develop their own harems. This is done by either gathering young fillies that are cast out from other harems on reaching sexual maturity, stealing mares from other stallion's harems, or trying to highjack an entire harem by taking on the stallion.

Fillies reach sexual maturity at three years of age (Barnett : 2007), and are either dispersed when they first display signs of oestrus or when their dam produces a new foal. Where a filly is able to choose the harem she joins there are two factors in her decision. Firstly, she will choose the one with the least chance of inbreeding; this is achieved by joining the harem of an unfamiliar male.

Secondly, her decision can be influenced by the ability to achieve a dominant position with the harem.

Courtship, Mating and Endocrinology

The courtship and mating process for the feral horse takes place over a number of days. The harem stallion is able to detect changes in his mares which indicate their sexual receptivity. The mare produces pheromones which are released by the preputial gland. The stallion adopts the flehmen position, raising the top lip to seal the nasal cavity, and is able to pick up pheromones in the mare's urine and faeces, by using the vomeronasal organ located within the nose. 'The vomeronasal organ is a paired hollow tubular structure' (Boyd and Houpt : 1994), which sends nervous messages in to the limbic system, including the hippocampus; driving mating motivation and controlling the production of male sexual hormones.

During the courtship process gonadotropin-releasing hormone (GnRH) is released by the hypothalamus within the mare's endocrine system. The GnRH influences the pituitary gland to release oxytocin, which stimulates contractions in the mare's reproductive tract thus helping sperm transport and reducing the time taken for the sperm to reach the oocyte. 'Oxytocin increases during the human female [sexual] response, peaking at orgasm, and is believed to facilitate orgasmic contractions' (Shakelford and Pound : 2006). Oxytocin also has an affect on the nucleus accumbens, which is the area of the brain responsible for feelings of pleasure and reward, it has also been shown to reduce feelings or anxiety and shyness in humans (Stephey : 2008). A study of voles found that higher oxytocin levels in the brains of monogamous pine voles compared to polygamous meadow voles (Insel and Shapiro : 1992), however a cross species comparison has been made for this work.

Visual signals are also displayed by the mare indicating to a stallion her sexual receptivity. 'She adopts a basewide squatting stance, urinates frequently, and rhythmically exposes the clitoris' (Houpt : 2005). The clitoris is devoid of melanin and is therefore pink in colour; this increases the visible signs of receptivity. The non-tactile senses that a stallion uses to gauge the receptivity of the mare will allow him to avoid the risk of injury or aggression.

This intricate courtship process allows both animals to be completely comfortable and relaxed with one another, further increasing the chances of a successful mating. If stress levels are lower in the mare during conception she is likely to stand better allowing an easier mating and a deeper ejaculation closer to the cervix. In a stud farm this is replaced by human observation for signs of receptivity, verified by a teaser stallion, before a mating by an unfamiliar stallion in the presence of stud hands. 'Sexual behaviour is very much a communicative process involving a complex series of

interactions, [therefore] it is potentially misleading to consider mare behaviour in isolation' (Curry, Eady and Mills : 2007).

A feral stallion may cover a mare up to 8-10 times in a 24 hour period (Davies Morel : 2008a) with a live foal rate of approximately 95% (Bristol : 1987); this is possibly due to the increase in the number of coverings. However repeated coverings may be ineffective due to spermicidal plug and the mare's immune reaction in the cervix. In the domestic situation, the stallion will usually only mate with the mare once, unless the mare is found to not be pregnant.

Difficulties and Problems in Mating

'Low sexual motivation/libido or poor mating ability are among the most common complaints in the [domestic] breeding stallion... the root cause of the problem has more to do with previous experience, current health, handling or management' (Stout : 2005). The stress experienced by the stallion is also a key factor for a successful mating. For a stallion to achieve an erection the parasympathetic nervous system must be activated. The parasympathetic system forms part of the autonomic system and is active during times of relaxation. If the stallion begins to associate mating with stress then erectile dysfunction or premature ejaculation can occur. This stress can occur if the stallion has had a bad experience during copulation, such as being kicked by an unreceptive mare. Stallions that have spent their early years within the racing industry and therefore not in the company of mares, may not be able to read signs of rejection, thus further increasing their chances of injury.

In the feral state a mare will choose a mate she considers to be strong and virile by observing the stature of the stallion. In the domestic state the mare has not been able to choose her desired mate and so can be aggressive. This can be particularly intimidating for a smaller stallion with a larger mare (McKinnon and Voss : 1995), and therefore engaging the sympathetic system leading to loss of libido and performance. The early withdrawal of a stallion close to ejaculation, due to the unwillingness of the mare, can cause damage to the engorged glanis penis, leading to pain and a bad association is formed with regards to mating. 'The stallion will not naturally dismount until his penile erection and engorgement of the glans penis has completely subsided' (Davies Morel : 2008a).

After mating the feral mare will walk forwards allowing the stallion to drop off her hindquarters. During in hand matings the stallion is forced backwards off the mare. This forced 'dismounting appears to represent an aversion or difficult experience' (McDonnell : 2000) for the stallion, causing stress and pain to the sacroiliac joint and therefore activating the sympathetic system and leaving the stallion prone to erectile problems. The covering schedule of a successful stallion can involve

mating with over 150 mares each season (Wood : 2004), this demanding routine will not allow sufficient time for the stallion to recover from any injuries he may sustain. This active calendar for coverings will also mean that the stallion will constantly be in the mental state required for mating, which is predominantly aggressive and can lead to an animal that is difficult to handle and control.

The annual birth rate of the feral mare has been shown to be between 0.36-0.60 per year with an average figure of 0.45 offspring per year (Garrott and Taylor : 1990). Domesticated mares are expected to be bred from on an annual basis. Figure 1 highlights the reduction in fertility rates following each successive foaling. The overall fertility rates for domestic horses will therefore be lower when compared to feral horses due to the frequency of foaling. However, a study of plains zebras revealed a negative correlation between natural inter-birth interval and the number of offspring reared by the mare ($t=-5.08$, $d.f.=29$, $P<0.0001$) (Pluháček, Bartoš and Čulik :2005).

Conception and apparent fertility rates according to parturition order of mares

Parturition order	Conception rate (%)	Apparent Fertility Rate (%)
1	75	71
2	73	68
3	71	68
4	69	67
5	67	65
6	64	61
7	62	59
8	59	56
9	56	54
10	54	52
11	48	47
12	48	46
> 13	41	38

Figure, 1. (Taveira & Silveira da Mota : 2007)

The manipulation of oestrus cycles occurs within the horseracing industry due to all thoroughbreds having the same birthday, January 1st. This is achieved by 'the use of artificial lighting to alter the mare's perception of day length' (HorseQuest : 2007), thus reducing the melatonin release from the pineal gland which restricts the hypothalamic-pituitary-ovarian axis, thereby encouraging the mare out of winter anoestrus early. Instead of the mare returning to a natural oestrus cycle in April the mare will start to become receptive from February. It is advantageous to have an earlier foal as there will be more time for growth and development before its first birthday. However, foals that are born before spring are born in adverse weather conditions, which may hinder the young foal from gaining outdoor life experiences during the first few months of its life.

The advantages for a domestic mare in terms of welfare and fertility are the administrative procedures and the standards of health and hygiene found in stud farms. The records kept by the

stud will be able to ensure that mares and stallions have received the correct vaccinations and worming programmes. Accurate records of matings are kept within the bloodstock industry and therefore it is easy to identify the parentage of any thoroughbred, providing the potential to prevent breeding horses with conformational or genetic weaknesses. The cleanliness routines employed by the stud will help prevent the spread of venereal diseases, such as endometriosis and EHV-1.

One of the maternal predictors for performance is racecourse performance. Mares that have performed well on the racetrack are more likely to have tilted pelvises; allowing faeces to enter the vagina causing infection. 'The problem can be corrected with a simple procedure known as Caslick's repair, developed by E.A. Caslick, D.V.M in the late 1920s' (Smith Thomas : 2001). The operation involves stitching the vulva to protect the vagina from faeces and infection. Prior to mating the procedure is reversed, however this can cause pain to the mare and therefore an association of the mating process with pain. This is not conducive to having a relaxed and comfortable animal to achieve a successful mating. 'Perineal and general conformation that predispose a mare to reproductive tract infections is inherited' (Davies Morel : 2008b) and therefore continued breeding from these animals will continue to pass on the deformity. In the feral horse, the infection would prevent those mares from breeding and the disposition would be breed out.

Conclusion

The majority of the fertility and welfare issues are caused by stress and the reliance by breeders on a limited number of stallions and the over production of mares. Breeding from mares in alternate years will replicate the behaviour found in the feral animal, benefiting from a higher fertility rate due to the lower parturition rate and in the case of mare's requiring a Caslick's operation, fewer surgical procedures.

Selecting bloodstock from a wider gene pool will allow greater genetic diversity and a decreased risk of inbreeding. This will also allow fewer matings per animal, increasing the time available for copulation and recovery leading to lower aggression and stress experienced by the animals. The copulation process could allow the mare and stallion to spend several hours together encouraging a bond to form, reducing apprehension, anxiety and the threat of injury. Multiple matings should also be permitted, as occurs in the case of the feral horse.

The skills and techniques of the handlers are also of vital importance. The employment of confident and experienced stud grooms means they will be more capable of settling and relaxing the horse. The handler should allow the stallion to remain on the mare after mating to allow disengorgement of the glanis penis and not push the stallion backwards off of the mare.

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