



Research

Effects of prompt versus stepwise relocation to a novel environment on foals' responses to weaning in domestic horses (*Equus caballus*)



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ABSTRACT

Artificial weaning is often highly stressful for both mother and offspring. We investigated the effect of 2 different weaning and relocation schedules on growth rate and saliva cortisol concentrations in a group of loose-housed domestic horses. We predicted higher acute stress (cortisol concentrations), but a lower long-term effect on weight gain, which would indicate lower chronic stress in foals, if the foals were moved to the new environment immediately after separation from the mothers (“prompt relocation” [PR]) compared with relocation that was adjourned for a week (“stepwise relocation” [SWR]). Within 2 seasons, 56 foals weaned at age of 165–250 days were regularly weighed up to 140 days after weaning. Growth rate significantly differed between SWR and PR foals. The PR weanlings revealed relatively stable increase in their weights, whereas SWR foals experienced a significant drop in growth during the first 3 weeks after weaning. The weight differences were still apparent 5 months after weaning (predicted weight, least squares means \pm standard error: 374.40 \pm 1.75 kg in PR vs. 362.71 \pm 1.66 kg in SWR foals). Cortisol concentrations changed significantly between and within different weaning procedures and were highest in PR foals after weaning and relocation. Compared with pre-weaning values, cortisol levels increased in PR but not in SWR foals, either after weaning or deferred moving. We found large individual variability in foals' growth and in cortisol concentrations for both weaning procedures. There was also a year effect in SWR foals. Stepwise changes of the physical and social environment (deferred removal to the remote facility) within a short period after abrupt weaning resulted in lower acute stress but induced long-term negative effects on foals' growth rate compared with joint weaning and relocation. Our results support rather prompt moving of the weanlings to the new facility, rather than to a stepwise location on horse breeding farms.

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Introduction

The breaking of the mother-offspring bond (whether natural or forced) often constitutes a highly stressful event for both mother and offspring, especially in the case of the artificial weaning of domestic animals (Weary et al., 2008). Recent pressure to improve the quality of welfare in animal management systems invites further discussion about weaning as a process and emphasizes a need for scientific investigations of the welfare

consequences of alternative weaning methods to better inform future management practice.

Natural weaning in equids is a gradual process that starts at about 8 months of age. Weaning termination depends mostly on the mare's body condition and her reproductive status. Pregnant mares usually wean their foals before 1 year of age when the next delivery approaches, whereas mares who failed to conceive in a subsequent season may commonly continue to nurse their yearlings up to 2 years of age (Berger, 1986; Cameron et al., 2000; Crowell-Davis and Weeks, 2005; Duncan et al., 1984; Pluháček et al., 2007; Rutberg and Keiper, 1993). Cessation of milk support, however, does not usually break the mother-offspring bond, and it frequently persists for several years in many mammalian species (reviewed in Newberry and Swanson, 2008), including horses. The bond between mother and offspring remains strong

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until the foal leaves the natal group at an age from 1 to 4 years (Khalil and Kaseda, 1997; Monard and Duncan, 1996; Tyler, 1972; Waring, 2003).

In contrast, foals born to domestic horses experience artificial weaning at much younger age than those born to wild horses. The attendant nutritional, social, and environmental changes may have long-lasting consequences for both mother and foal (Apter and Householder, 1996; Henry et al., 2012). Weaning of foals under farm conditions may occur as early as immediately after birth but is more commonly undertaken at the age of 4–8 months (Apter and Householder, 1996; McCall et al., 1985; Rogers et al., 2004; Weeks et al., 2000). Time of weaning on horse farms reflects the tradeoff between the 2 opposite concerns for the breeders: the condition of the mare which could result in earlier weaning (Ladewig et al., 2005), and the effect on developmental and behavioral aspects for the foal, which results in a tendency to delay weaning. The allocation of maternal care in pregnant mares may have an additional effect on concerns about the condition of the mare (Bartošová et al., 2011).

In the most widespread weaning practice, abrupt weaning, the mare and foal are suddenly and completely separated by enough distance to prevent them seeing, hearing, or smelling each other (Apter and Householder, 1996; Ladewig et al., 2005; McCall et al., 1985). Besides loss of mother and milk (Coleman et al., 1999; McGee and Smith, 2004), abrupt weaning process typically imposes additional change on the foal including a new unfamiliar environment or mixing with new social partners (Haupt and Hintz, 1983; Newberry and Swanson, 2008; Nicol et al., 2005). These changes can elicit various behaviors in foals that may include increased locomotion and vocalization, and stereotypic or self-destructive behavior (Haupt and Hintz, 1983; McCall et al., 1985; McGee and Smith, 2004; Nicol and Badnell-Waters, 2005). Abrupt change may increase the incidence of health problems associated with growth curve deviations that usually occur immediately after weaning (Haupt et al., 1984; Rogers et al., 2004; Warren et al., 1998).

Given these potential repercussions of abrupt weaning, various alternative methods have been subjected to detailed research (reviewed in Apter and Householder, 1996; Waran et al., 2008), including gradual weaning (Rogers et al., 2004), partial separation allowing fence-line contact between mothers and foals (McCall et al., 1985), weaning in pairs (Hoffman et al., 1995; Malinowski et al., 1990) or groups (Heleski et al., 2002), weaning in paddocks with the possibility of grazing (Heleski et al., 2002; Nicol et al., 2005), weaning with a presence of some unrelated adult horse(s) (Henry et al., 2012), and feeding different diets at the time of weaning (Coleman et al., 1999; McCall et al., 1985; Nicol et al., 2005). These more weaning techniques that mimic parts of natural weaning appear to be associated with lower levels of stress in both mother and foal, but the various studies undertaken are not easily comparable owing to different methodologies and differences in measures recorded.

Evaluation of stress levels in foals has been based on various indicators, including the foals' behavior [including locomotion, vocalization, or abnormal behavior (Heleski et al., 2002; Henry et al., 2012; Haupt et al., 1984)]; activity (McCall et al., 1985); blood cortisol levels (Berger et al., 2013; Hoffman et al., 1995; Haupt et al., 1984; Malinowski et al., 1990; McCall et al., 1987); salivary levels of cortisol and other compounds (Erber et al., 2012; Henry et al., 2012; Moons et al., 2005); growth rates (Coleman et al., 1999; Erber et al., 2012; Rogers et al., 2004; Warren et al., 1998); and weanlings' trainability, tractability, and responses to a novel object (Nicol et al., 2005). Stress affects normal biological functions (e.g., growth) through biological responses that are used to redress stressful situations (Moberg, 1987; Morgan and Tromborg, 2007).

Resources (energy) allocated to the activities assisting the animal to cope with stress, such as vocalization, locomotion, stereotypic behavior, increased heart rate and respiration, or increased secretion of various isomers of adrenal glucocorticoids, are unavailable for biological needs such as growth (Moberg, 1987; Morgan and Tromborg, 2007). Body weight reduction or growth rate disruption as a consequence of the stress has been documented in multiple species [laboratory mice (Bartolomucci et al., 2004; Laugero and Moberg, 2000a, 2000b, 2000c), rats (Konkle et al., 2003; Marti et al., 1994), and domestic pigs (Hemsworth et al., 1981; Pluske et al., 1997)]. Increases in cortisol level and reduced weight gain have been used as indicators of exposure to stressful situations including weaning (Erber et al., 2012; Malinowski et al., 1990; Rogers et al., 2004).

Despite the potential negative repercussions of abrupt weaning, it is still common because it is considered easier and more cost-effective than gradual separation of mother-foal pairs (Apter and Householder, 1996). On some farms, management practices that separate actual weaning (separation from the mother) from other subsequent changes in foals' life (change of wider social group and change to an unfamiliar environment) have been introduced as an alternative measure to help the foals cope better with loss of the mother within familiar environment. Staying in the home environment after weaning has been found to be less stressful than relocation in weaned piglets (Ekkel et al., 1995; Hoetzel et al., 2011; Puppe et al., 1997), farmed wapiti calves (Church and Hudson, 1999), cattle calves (Lynch et al., 2011), and horse foals (Nicol et al., 2005). Nevertheless, little is known about the effects of later removal of the "home-weaned" offspring to unfamiliar environment. Deferring moving to 35 days post-weaning resulted in a less marked stress response in pastured beef calves compared with simultaneous weaning and moving to the unfamiliar environment (Lynch et al., 2011). In contrast, weaning stress intensifies with increasing numbers of challenges imposed on the young (Enriquez et al., 2011; Newberry and Swanson, 2008; Waran et al., 2008; Weary et al., 2008) so that dividing the weaning-associated changes in the foal's life into a sequence of partial changes might result in higher overall stress even if each sequence is less stressful.

We investigated the effect of different time schedules of moving to a new environment after abrupt weaning on growth rate and saliva cortisol concentrations, in a group of loose-housed domestic horses.

Materials and methods

Animals and study site

We observed 56 foals of the Kladruby horse, a native Czech warm-blooded horse breed (breed standard: average height at the withers 164 cm, average weight 570 kg) at the National Stud Kladruby nad Labem, Czech Republic (50°3'29"N, 15°29'4.998"E) in 2 consecutive seasons. Numbers of observed foals are shown in Table 1. Age of the foals at abrupt weaning ranged from 165 to

Table 1
Numbers of observed foals in the 2 observation years and weaning procedures

Number of horses/season	Season 1	Season 2	Total
Males	11	18	29
Females	16	11	27
Total	27	29	56
Stepwise relocated foals	14	15	29
Promptly relocated foals	13	13	26

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