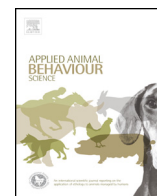




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## Crib-biting and its heritability in Finnhorses

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### ABSTRACT

Crib-biting in horses is a stereotypical oral behaviour with a prevalence of 2.8–15%, varying between breeds. A genetic basis for crib-biting has been suggested by many researchers, but due to incomplete information on families or the lack of a sufficient number of verified crib-biters, heritability has not been determined for any horse population. However, the involvement of inheritance in behavioural traits has only been indicated by a few studies in horses, and evidence for a genetic component in stereotypies mainly comes from studies on other species.

Our aim was to estimate the heritability of crib-biting behaviour in a Finnhorse population. The cold-blood Finnhorse is a native breed that has been pure-bred since 1907. All Finnhorses are registered in the Finnhorse register, and pedigree data are available for more than 10 generations. A cohort of 111 crib-biting and 285 non-crib-biting (control) Finnhorses were recruited through advertisements. Our hypothesis was that crib-biting is a quantitative trait with a reasonably high heritability ( $h^2$ ), because there is some anecdotal evidence that the trait is expressed in certain families. To the best of our knowledge, this is the first time that  $h^2$  has been estimated for crib-biting behaviour in any horse population.

The crib-biting behaviour of Finnhorses was described in more detail through an owner questionnaire. Crib-biting appears to be performed by Finnhorses in quite a similar way to other breeds. According to the owners, Finnhorses most frequently crib-bite shortly after feeding on concentrate or titbits and in stressful situations. The habit typically begins during the juvenile years or after some traumatic phase. The proportion of mares among cases was smaller than among controls.

Linear and threshold animal models were tested to estimate the heritability, but the estimates did not converge within allowed parameter space. Hence a more robust linear sire model was used in the final analysis. The estimated heritability of the trait was 0.68. Higher than moderate heritability suggests for further association studies at the genome level together with pedigree studies to identify risk loci. In addition, resolving genetic correlations between performance traits and crib-biting is of great interest for breeding purposes. This study represents a preliminary stage in genetic research of crib-biting.

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### 1. Introduction

Crib-biting in horses is a stereotypical oral behaviour (Ödberg, 1987). A crib-biting horse grasps a fixed object with its incisor teeth and contracts the lower neck muscles to retract the larynx caudally (Lebelt et al., 1998). The prevalence of crib-biting is 2.8–15%, varying between

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breeds (Luescher et al., 1991; McGreevy et al., 1995b; Waters et al., 2002), and a horse may perform crib-biting bouts for up to 6 h a day (Mason, 1991). Crib-biting horses have a high motivational need for this behaviour (Haupt, 2012). Stress, lack of enough roughage, gastric discomfort and frustration caused by stall restrictions as well as weaning conditions have been suggested as a causal basis for a horse to initiate crib-biting (Cronin et al., 1985; McGreevy et al., 1995a; Nicol et al., 2002, 2005). The majority of equine oral stereotypies start within one month of weaning (Waters et al., 2002). Nagy et al. (2008) found that a weaning neighbour increased the risk for weaving, but effect of crib-biting neighbour was not significant. Crib-biting is not seen in feral horses, but in Przewalskii horses in zoos the frequency was found to be about 4% (Marsden, 1995). Once established in daily behaviour this behaviour is very resistant to environmental enhancements. McBride and Hemmings (2009) suggested that equine stereotypies may be result of life history of chronic stress in combination with predisposed genotype. Stress may cause the release of  $\beta$ -endorphin in the brain, stimulating dopamine release and activating these basal ganglia motor programmes (Dodman et al., 1987). Supporting this, a knock-out mice for the hyperdopaminergic, genetically modified dopamine transporter gene (DAT) display a type of behaviour known as superstereotypy: excessively strong and rigid manifestations of complex and fixed action patterns (Berridge et al., 2005). Arousal from behavioural frustration was suggested by Ödberg (1987) as a common factor that links different forms of stereotypies.

Vecchiotti and Galanti (1986) demonstrated through pedigree studies the involvement of inheritance in three abnormal behaviours, including crib-biting, but due to incomplete information on families, heritability could not be determined. Estimations of the heritability ( $h^2$ ) of horse behaviour traits are rare, but association analysis between genes and personality traits (Momozawa et al., 2005) and comparative studies (Wade et al., 2009; Schröder et al., 2011) are more common. Genetic characterization of abnormal behaviour has been studied in dogs (Liinamo et al., 2007; Pérez-Guisado et al., 2006; Dodman et al., 2010), and evidence for a genetic component in stereotypies mainly comes from small mammals, such as striped mice (Jones et al., 2008). In mice, chronic stress early in the animal's development is associated with the predisposition to stereotypy (Cabib and Bonaventura, 1997; Weaver et al., 2004), and this sensitivity is suggested to be genotype dependent (Cabib et al., 1985; McBride and Hemmings, 2005) or due to epigenetic programming (Weaver et al., 2004). However, the mode of inheritance in behavioural traits is usually complex (Andersson and Georges, 2004), and some quantitative trait loci (QTLs) may exist. Although crib-biting may present itself in an all-or-none manner, the underlying genetic predisposition to the character may be assumed to be normally distributed (McGuirk, 1989). Calculating heritability on the underlying scale provides a more reliable basis for predicting or explaining responses to selection for a trait, where the predisposing causes of the condition may vary in different environments (McGuirk, 1989). The heritability of behavioural traits in animals varies widely. For example,  $h^2$  was found to be

0.16–0.20 for tameness in the blue fox (Kenttämies and Smeds, 2003), and 0.2–0.81 for aggressive behaviour in dogs (Pérez-Guisado et al., 2006; Liinamo et al., 2007).

The cold-blood Finnhorse is a native breed that has been pure-bred since 1907, and the European Union has defined the Finnhorse as an original breed. All Finnhorses are registered in the Finnhorse register, and pedigree data are available from over 10 generations. The Finnish Trotting and Breeding Association (Suomen Hippos) serves as a registry for horses and maintains breeding and racing information and records. According to Suomen Hippos ([www.hippos.fi](http://www.hippos.fi)), the number of Finnhorses exceeded 400,000 in the 1950s, but declined below 100,000 in the late 1960s and was at its lowest in 1987, being only 14,100. The number of registered Finnhorses in 2012 was 19,700, with approximately 1400 foals born annually. Four lines of the breed can be traced, including trotters, riding horses, working horses and small pony-sized horses. A known crib-biting Finnhorse may not be accepted in the studbook, which reduces its value in breeding.

The aim of this study was to estimate the heritability of crib-biting behaviour in a Finnhorse population. Another aim was to collect phenotypic descriptions of crib-biting through a survey of owners.

## 2. Materials and methods

### 2.1. Animals

Data on a cohort of crib-biting (case) and non-crib-biting (control) privately-owned Finnhorses were collected during 2009–2013. The data were originally collected for a case-control study. Horses were recruited through advertisements on the University of Helsinki website, as well as in the Veterinary Teaching Hospital, private horse clinics and domestic horse magazines. All horse owners who wished to participate completed a consent form (electrical or paper) in which they classified the horse as a crib-biter or a non-crib-biting control horse. A definition of crib-biting was provided in the consent form. Crib-biters can be identified by their owners without difficulty due to the typically emitted grunting noise, which is not easily confused with any other behaviour. The criteria for controls were that they were at least 10 years of age and without a history of crib-biting, but approximately 10% of control horses selected during data collection were aged 6–8 years to balance the study populations (cases and controls). The non-crib-biting status for most of these horses was verified by e-mail in 2013 before analysis. A description of the cases and controls is provided in Table 1. The pedigree data was received from The Finnish Trotting and Breeding Association (Suomen Hippos).

More detailed phenotypic information on crib-biting behaviour was obtained through an owner-completed questionnaire (Supplementary 1). This information included situations when the horse performed crib-biting behaviour and how long crib-biting had continued. The data from the questionnaires were also partly presented in our recent molecular biological report describing the

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