A new approach to horse welfare based on systems thinking

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Abstract

*Globally, calls for change in the horse industry to prioritise the health and well-being of domestic horses (*Equus caballus*) are reaching a critical threshold. Horse behaviour deemed undesirable or inconvenient by owners (henceforth referred to as undesirable behaviour) is reported across all aspects of a horse's life and may indicate a welfare issue. This study proposes a reconceptualisation of undesirable horse behaviour as a complex challenge based on systems thinking. Emerging from the natural sciences, systems thinking is an interdisciplinary approach to complex challenges (such as undesirable behaviour) as dynamic, highly interconnected networks of components and feedback relationships. This critical literature review examined the undesirable behaviours studied, the disciplines conducting research and their underpinning assumptions to identify opportunities for approaching research differently. Four themes emerged from the literature: undesirable behaviour is typically studied with unarticulated assumptions and in individual disciplines; behaviours are typically studied in isolation with the complexity of horse-human interactions generally not considered; management of behaviour typically has an anthropocentric linear 'cause and effect' focus; and solutions to undesirable behaviour are often short-term 'fixes' resulting in poor horse outcomes. From these, we outline the opportunities that each provide the next generation of horse research in terms of interdisciplinarity, systems thinking and management. Undesirable horse behaviour in a horse-human system is conceptually mapped in terms of factors associated with the behaviour (eg housing, stress, diet), and the relationships between them. Systems thinking offers a way to integrate multiple disciplines and identify and navigate new solutions to promote horse welfare.*

Keywords: *animal welfare, horse behaviour, horse training, stereotypy, systems thinking, undesirable behaviour*

Introduction

A need for change in the horse industry

There is a growing call for change in the diverse and multi-billion dollar, global horse (*Equus caballus*) industry to promote healthy horse behaviour. Describing this industry as an ancient "anthropocentric hall of mirrors", McLean (2013; p 135) highlights that many horse-keeping and training practices could be updated to capture contemporary ideas of science and ethics. Many influential researchers are similarly calling for change which leads to better outcomes (Jones & McGreevy 2010; Bergmann 2020; Mellor 2020). Archeological evidence suggests the keeping and riding of horses has been practiced for around 6,000 years (Goodwin 2003). Traditional practices remain central to the horse industry, despite a lack of ethological or scientific evidence to support their continued use. For example, the trainer Xenophon (430–354 BC), a pupil of Socrates, is still revered today as one of the great masters (van Weeren 2008). It has also been noted that traditional horse-keeping

and training, based on these ancient treatises, does not consider the sentience of horses (Lupton 1884; Ruet *et al* 2019), a concept that is likely to be crucial in providing horses "a life worth living" (Mellor 2016; p 3).

Despite a long history of domestication, it would appear horses continue to face numerous and significant welfare challenges. Large-scale reports have identified that horses are facing issues such as neglect, inappropriate housing, owners' lack of knowledge, and unrecognised or ignored stress/pain behaviour (World Horse Welfare 2015; Horseman 2017). In the developed world, horses are used primarily for racing, sport, therapy and entertainment (Robinson 1999; Jones & McGreevy 2010). Using an animal for sport or recreation bestows a heavy ethical burden on participants to ensure the well-being of the animal is not compromised (Jones & McGreevy 2010). Yet concerns for horse welfare across all sectors persist, threatening the industry's acceptability to the public (Hampton *et al* 2020; Heleski *et al* 2020). Scientific organisations recognise the issue, recently highlighting the 'ethical

tightrope' walked by the horse industry and the constant need to challenge the *status quo* (International Society of Equitation Science 2021b; p 17). In addition, a recent assessment of the industry's social licence to operate deemed it at the level of "tolerated/accepted" by the community, only one step away from losing its social licence to operate (International Society of Equitation Science 2021b). Thus, it has been argued that continuing the many practices which exploit and commodify horses, such as continuing to keep horses in unsuitable housing which fails to meet their needs in multiple ways but is convenient for owners, is endangering the long-term ethical sustainability of the industry (Bergmann 2015).

Research challenging the ethical sustainability of the horse industry (Jones & McGreevy 2010; Bergmann 2015) is relatively new, given the millennia's old traditions of keeping and training horses (Goodwin 2003). However, it is likely many horses have been experiencing poor welfare for much of these past millennia, suggesting a new approach to horse care and training is long overdue. It should be noted that consistent with the purpose of this review, which is to reframe horse-human interaction to achieve a more horse-centred focus, the commonly used anthropocentric term horse management will be replaced with the horse-centred term horse care. This review will use horse behaviour that is deemed undesirable by owners and riders (henceforth referred to as undesirable behaviour) as a vehicle for developing a new approach. Although a horse's behaviour may be inconvenient for its human owner, behaviour represents the only communication channel available to the horse. Undesirable behaviour is widely reported both in the stable and under saddle and can serve as an entry-point for considering the quality of life of horses (Hockenhull & Creighton 2013; Carroll *et al* 2020). On the ground, undesirable behaviour includes stereotypies such as crib-biting, weaving and box-walking; aggression towards humans and barging. Examples of ridden undesirable behaviour include bucking, rearing, bolting and refusing to move forward when asked (Hockenhull & Creighton 2012). Such behaviours can result in harsh training and may lead to relinquishment (Hockenhull & Creighton 2012, 2013), or euthanasia (Ödberg & Bouissou 1999) if the horse is deemed dangerous or unfit for purpose. As such, in pursuit of promoting change to deliver better welfare outcomes for horses, this paper seeks to reframe the way researchers approach the study of horses and horse-human interactions. It is proposed that the keeping and training of a horse so that the horse can be ridden and participate in sport, racing or therapy, without compromising their quality of life represents a complex challenge. Undesirable behaviour and its link to horse welfare will be used to illustrate a new scientific approach.

In this paper, we draw upon undesirable horse behaviour as an entry point for reconceptualising how horses are managed and trained in order to promote their quality of life. We examine the literature of undesirable horse behaviour in the horse-human relationship, including: the

behaviours and factors studied; and the disciplines conducting research, along with their respective underpinning assumptions, in order to identify opportunities for reconceptualising horse research. In the sections that follow, we contextualise the contemporary challenge of undesirable horse behaviour in the horse industry. Coming from the disciplinary backgrounds of animal behaviour, psychology, and environmental sociology, we outline traditions in science that frame the scientific method and present systems thinking as an integrative approach that can disrupt dominant frameworks for studying horse-human interactions, bring together multiple disciplines, and facilitate interdisciplinary and innovative responses to this complex challenge. We explore how reconceptualising the challenge of undesirable horse behaviour from a systems thinking approach can bring the horse into focus.

Defining undesirable horse behaviour

Central to this study is the notion that undesirable horse behaviour occurs across all aspects of a horse's life including while being ridden and signals a potential welfare issue for the horse. Using undesirable horse behaviour allows for a broad examination of the research into various facets of the horse industry. The physical and psychological well-being of horses is primarily evaluated by behavioural indicators, and thus observing behaviours can be a window into a horse's quality of life (Hall & Heleski 2017). We conceptualise 'undesirable horse behaviour' as an aggregation of behaviours that can be studied across all aspects of a ridden horse's life (Hockenhull & Creighton 2013; Hall & Heleski 2017). Undesirable behaviours can be related to poor riding practices, use of certain equipment, poor horse care and poor training practices (Odberg & Bouissou 1999; Hockenhull & Creighton 2013; Lesimple *et al* 2016a). Horses can express stereotypical behaviours, aggressive behaviour such as biting and kicking, extreme ridden behaviours such as bucking (sudden humping or arching of the back with the head and neck lowered), rearing (a sudden postural change so the horse stands only on its hind legs), and bolting (running away at a gallop where the rider has no control), and less extreme behaviours such as spooking (sudden sideways leaping of the horse), head-tossing and crabbing (where the horse fails to go straight) (McGreevy *et al* 2005). Stereotypical behaviours are generally believed to be a coping response related to psychological stress and physical deprivation (Mason 2006; Briefer Freymond *et al* 2020). In comparison, several undesirable ridden behaviours have been described as 'conflict behaviours' which are often attributed to confusion in the horse (McGreevy *et al* 2005), however other authors have attributed these behaviours to pain (Cook & Kibler 2018; Dyson & Van Dijk 2020; Mellor 2020). Irrespective of their cause, it is becoming increasingly apparent that undesirable horse behaviour signals a largely unrecognised welfare problem for the horse (Lesimple & Hausberger 2014; Horseman 2017; Bergmann 2020; Mellor 2020) that needs to be closely examined and made more salient to all involved.

Crib-biting as an illustrative example

Due to the serious welfare issues it presents for the horse and the high degree to which it has been studied, crib-biting is used as an illustrative example throughout this paper. However, it is worth noting that the purpose of this paper is not a systematic review of the crib-biting literature. Crib-biting is common in intensively managed horses, its causes are not well understood but are thought to be linked to isolation, confinement and concentrated feed (Clegg *et al* 2008). This stereotypy involves the horse grasping a solid object and appearing to engulf air (Cooper & McGreevy 2002). Once established, researchers have shown that the motivation to crib is as strong as the horse's motivation to eat, the force exerted for each crib-biting movement can be enough to lift a 30-kg weight (Houpt 2012) and horses can perform the movement over 1,000 times each day (Clegg *et al* 2008).

The benefits of a systems thinking approach

Modern reductionist science sees the world and all its inhabitants as analogous to a machine that can be broken down into its constituent parts and studied (Capra & Luisi 2014). In addition, a common view of modern science is that it seeks to dominate and control nature (Walsh *et al* 2021). This seventeenth century way of thinking and seeing the world, has presided over science for three hundred years, yielding some remarkable achievements, such as cell biology, modern genetics, and Newtonian mechanics (Capra & Luisi 2014). However, it may also be responsible for some of the many welfare issues horses currently face. The mechanical solutions afforded by linear thinking to manage crib-biting can be used by way of illustration. Crib-biting is thought to be a behavioural coping mechanism related to the stress and deprivation associated with stabling (Ruet *et al* 2019; Briefer Freymond *et al* 2020). Two linear solutions to crib-biting are surgical procedures and cribbing collars (a tight anatomical collar, sometimes with a metal spur on the inside, designed to make it painful for the horse to flex its neck). Alternative scientific approaches which use non-linear thinking, and view the world as a harmonious, inter-related system where the whole is more than the sum of the parts (Capra & Luisi 2014), are likely to arrive at more holistic solutions to crib-biting, such as a change in horse care. The prevailing mechanistic framework has allowed significant advances in understanding equine behaviour, equine health requirements and training techniques. However, despite these advances, high rates of undesirable horse behaviour and poor horse welfare remain. This suggests there is a need for a new approach which transforms the science from examining horses solely using reductionist principles and disciplines operating in silos, to a non-linear systems framework which demands a more integrated, interdisciplinary approach.

Systems thinking has a long history as an interdisciplinary approach to conceptualising and navigating complex challenges such as sustainability and climate change (Gunderson & Hollong 2002). Application of systems thinking can foster the integration of multiple knowledges and support the development of interdisciplinary approaches. Systems thinking can be applied to reframing undesirable horse behaviour, seeing contexts as an interconnected network of components and relationships (Ostrom 2007), in this case the horse and the infinite aspects of its life (food, housing, training, human relationships and so on). Each of these components in a system are related through a series of feedbacks (Chapin *et al* 2000), for example, the feed that a horse consumes and its energy level. Different to scientific scholarships that focus on reductionist principles and the assumption that a phenomenon can be objectively studied in steady state, systems thinking is underpinned by the assumptions that systems are continuously changing and adapting to change; that relationships in the system are non-linear; and that uncertainty is an inherent quality of the system due to certain components, relationships or dynamics of a system remaining unknown (Berkes *et al* 2003; Capra & Luisi 2014). Systems can be visually represented and examined through mapping the components and relationships within a selected boundary (eg Bennett *et al* 2009). Relevant to the study of horses, systems thinking would regard the system of the horse as continuously changing and adapting to change, the relationships in the system would be interconnected with feedbacks, and that it is inherently impossible for the entirety of the horse system to ever be known, and that this becomes a crucial part of the care of the horse.

Study aim

The following critical review of the literature aims to examine the current approach to researching horse welfare using undesirable horse behaviour as a focus, and cribbing as a specific example throughout the paper. Further, we will then explore how adopting a systems thinking framework may provide academics a new perspective on how to approach horse welfare research which, in turn, may lead to better horse welfare outcomes.

Materials and methods

The review of the literature was undertaken by searching the databases ProQuest, Wiley Online and Science Direct, for the years 2010 to 2021, using the search terms 'equine', 'horse', 'behaviour', 'conflict', 'abnormal', 'problem', 'stereotype.' Much of the work in this area has been completed since the advent of equitation science in 2007 (International Society for Equitation Science 2021a). And one of the goals of this paper was to provide a snapshot of contemporary practices and the level of undesirable behaviour, so on this basis it is argued that a review of the literature from the previous eleven-year period was appropriate.

Searches were limited to studies published in English, full-text and peer-reviewed. Reviews, case studies, opinion pieces and editorials were excluded. The search yielded 714 papers, which included 48 duplicates, reducing the number to 666 papers, an additional six papers were found by reading reference lists, taking the total to 672 papers. The goal of this review was to capture the literature available on undesirable horse behaviour. Therefore, no papers were excluded due to
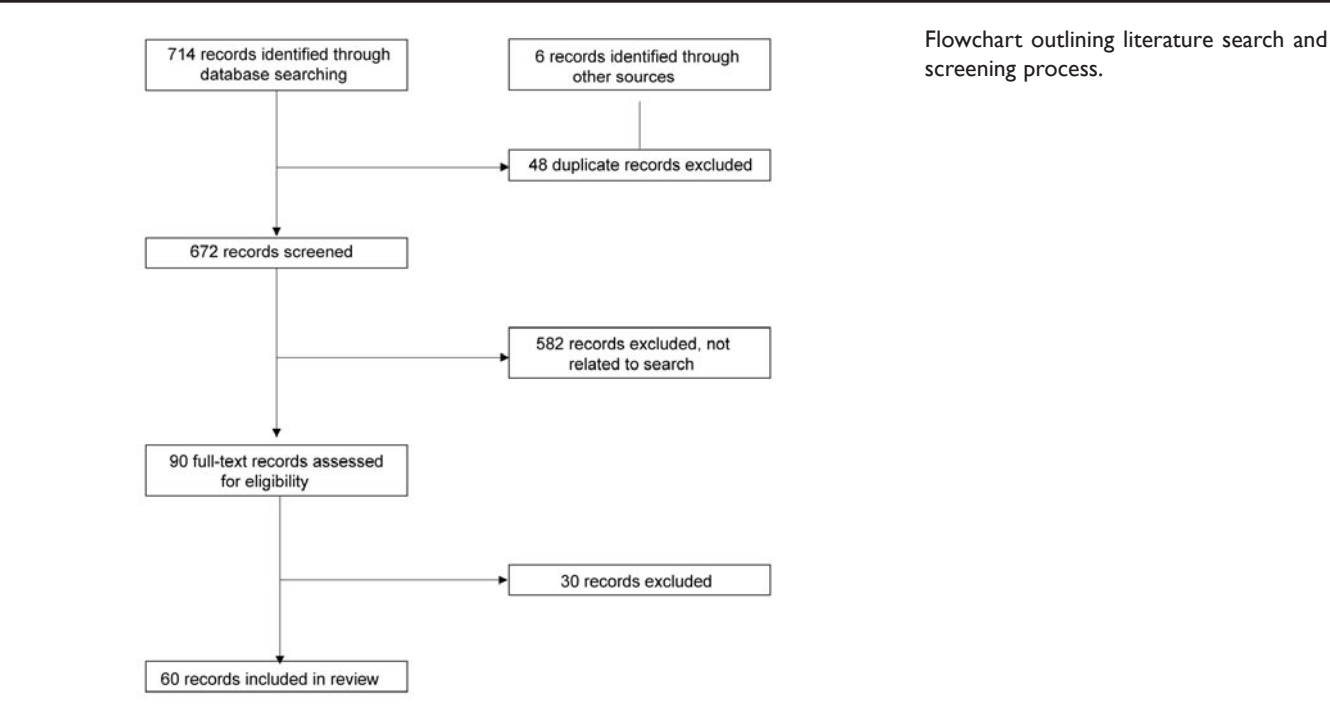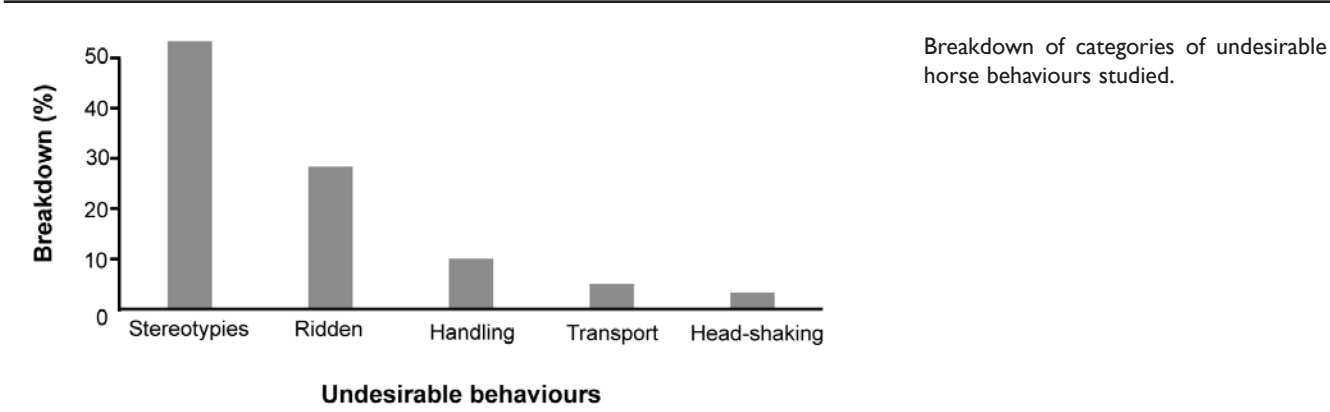
Figure 1

Flowchart outlining literature search and screening process.

Figure 2

Breakdown of categories of undesirable horse behaviours studied.

participant demographics or method of data collection. Of the 672 bibliographic records screened, 90 papers met the search criteria. After thorough reading of the full manuscripts, the number of papers which met the inclusion criteria was reduced to 60 papers (see Figure 1). Inclusion criteria were that the paper must have some measure of undesirable horse behaviour reported in the results section of the paper. Papers were retained if they met this criterion even if undesirable behaviour was a secondary measure. An example of one study that appeared very promising but that was excluded was that by Lesimple *et al* (2010) "Human direct actions may alter animal welfare, a study on horses (*Equus caballus*)", however this study does not report on undesirable behaviour, but instead looks at horses' posture, horses' spinal condition and the manner in which they were ridden. Using the search and selection strategy described above, it should be noted no qualitative papers were returned.

Categories of undesirable horse behaviour

The review of the literature reveals undesirable behaviours researched can be broadly classified into five main groups: stereotypies, ridden behaviours, handling behaviours, transport-related behaviours and head-shaking, with over 50% of studies focused on some aspect of stereotypic behaviour (see Figure 2).

The included papers show that undesirable behaviours are exhibited across almost all aspects of a horse's life: in the stable (Hockenhull & Creighton 2015; Hanis *et al* 2020), while being attended to by the farrier or veterinarian (Mansmann *et al* 2011; Pearson *et al* 2020), during transport (in particular during loading) (Padalino *et al* 2017), and while ridden (Hockenhull & Creighton 2012). The spectrum of undesirable horse behaviours includes abnormal stereotypic behaviours such as weaving and crib-biting (Ruet *et al* 2019) through to normal, but highly

Figure 3
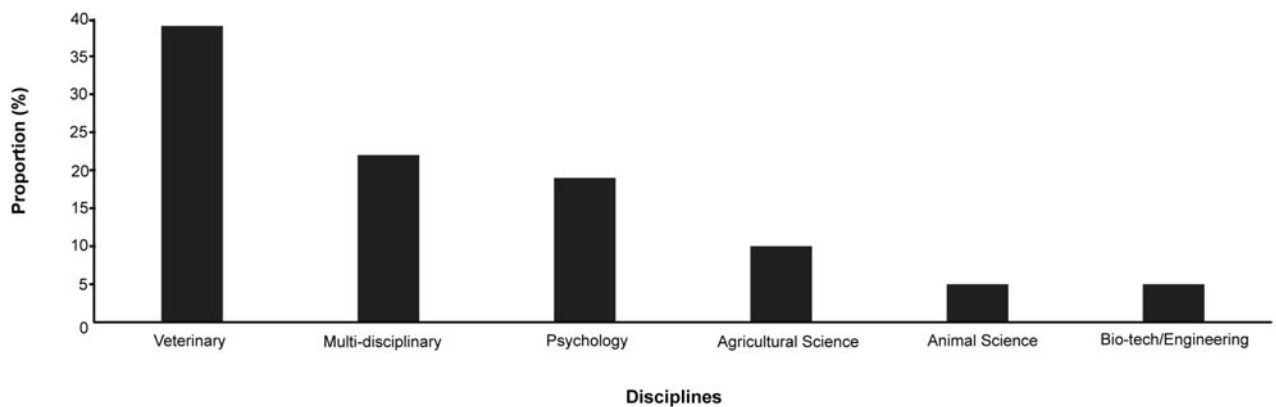
Overview of disciplines investigating undesirable horse behaviour.

Table 1   Risk factors reported in the literature related to undesirable horse behaviour.

Stereotypy	Ridden	Handling	Transport	Head-shaking
Stabling	Injury	Training	Separation	Nerve pain
Social isolation	Training	Difficulty of task	Novel objects	Musculoskeletal pain
Amount of forage	Teeth	Riding		
Ulcers	Rein tension			
	Saddle fit			
	Rider weight			
	Posture			
	Ulcers			
	Laminitis			
	Hoof malformation			

dangerous behaviours such as bucking and rearing while being ridden (Hockenhull & Creighton 2012).

Disciplines investigating undesirable horse behaviour

The disciplines researching undesirable behaviour in horses primarily come from traditional science fields, with the majority of research conducted by veterinary scientists and psychologists (Figure 3). Interdisciplinary research groups, made up most often by veterinary scientists and psychologists, represent just over 20% of publications. Often, interdisciplinary groups function as multidisciplinary groups where research is additive, as opposed to integrated interdisciplinary teams (Roy *et al* 2013; Annan-Diab & Molinari 2017). The interdisciplinary studies included in this review were based almost exclusively on a positivist scientific paradigm, however this assumption is almost never discussed in the papers themselves. As previously mentioned, the disciplines most commonly involved were veterinary science, psychology and animal science, which have a shared ontological and epistemological view.

Risk factors for the development of undesirable horse behaviour

Across the included literature, the risk factors identified that were related to undesirable behaviour were many and varied (see Table 1).

Stereotypical behaviours were by far the most studied, and common to all was the stabling of horses. The thread which united all undesirable behaviours was physical or psychological distress or pain, although in many studies the cause may not have been articulated using this language. Training which does not follow established learning theory principles has been identified as a risk factor for undesirable ridden behaviour (McLean & Christensen 2017), however on closer inspection, most examples of poor training result in some form of pain or distress for the horse. A common example is riders that chronically apply both 'go' aids using leg pressure (on the horse's sides) and 'stop' aids via rein pressure (to the horse's mouth) simultaneously as a means to coerce a horse into a particular posture. Clearly, the horse

cannot respond appropriately to both aids, no being can go and stop at the same time. Such training results in both stress and pain for the horse and increases the likelihood of undesirable behaviour, sometimes referred to as conflict behaviour. Conflict behaviour is most often described during riding and is essentially a subset of undesirable behaviour in horses (Górecka-Bruzda *et al* 2015; Waite *et al* 2018; Christensen *et al* 2021). Conflict behaviour is generally accepted as being a hyper-reactive response to pain caused by forceful or unrelenting application of negative reinforcement pressures (McLean & Christensen 2017). Poorly timed or incorrect use of negative reinforcement or the use of pressure cues which exceed tolerable limits, transforms negative reinforcement into punishment, which can trigger undesirable and (often) dangerous flight responses (McLean & Christensen 2017). Another common example is a rider applying a leg aid with a spur who continues to apply the spur even though the horse has offered the correct response. The relentless driving aid (the leg and spur pressure) from which the horse cannot escape then ceases to act as a negative reinforcement cue and becomes punishment, which is essentially pain inflicted on the horse from which it tries to escape (conflict behaviour).

The undesirable behaviour of crib-biting

Of the included papers, 17 had some kind of measure of crib-biting behaviour, although not all reported specifically on crib-biting, some reported on stereotypies as a group, of which crib-biting was one (Table 2; see supplementary material to papers published in *Animal Welfare*: https://www.ufaw.org.uk/the-ufaw-journal/supplementary-material).

Of the 17 included papers, eight were published in *Applied Animal Behaviour Science*, seven were published in a veterinary journal (for example, *Equine Veterinary Journal*), one paper was published in *Physiology and Behavior* and one in *ISRN Zoology*. None of the included papers explicitly discuss the ontological or epistemological assumptions underpinning the research, however this is not unusual with most researchers leaving this aspect of their research implicit (Wahyuni 2012). In terms of providing recommendations to address crib-biting: eight papers did not provide any recommendation (or the recommendation suggested was not yet available, for example one paper recommended genetic testing); five papers made recommendations around feeding and housing but with no specific detail; one recommended a commercial device to slow down the eating of concentrate feed; one suggested that stall design be considered when building stables; and finally, one recommended surgery as the treatment of choice for crib-biting (see Table 2; https://www.ufaw.org.uk/the-ufaw-journal/supplementary-material).

Discussion

From unarticulated assumptions and individual disciplines to interdisciplinarity

The ontological and epistemological assumptions underpinning science are rarely discussed in much scientific literature, and the studies included in this review follow this tradition. As is the case in most positivist research, it is assumed that there is a single knowable reality; the researcher, and therefore the research, is objective; and reality can be studied through experimentation to discover immutable facts (Wahyuni 2012). In studying domestic horse behaviour, where the horse is entirely dependent on humans for almost every aspect of its life, such an ontological standpoint is infelicitous as it fails to acknowledge that the reality of a situation for a horse may be vastly different to the reality experienced by its owner. It may be that not only does research in this area require the input from disciplines outside the sciences which utilise different philosophical underpinnings, but the scientific disciplines such as veterinary science and psychology could explore the benefits that such differing philosophical approaches might bring.

In order to engage with systems thinking for addressing undesirable behaviour, there is a need to bring together multiple disciplines and expertise to both frame and address the problem. The findings show that most research into undesirable behaviour is occurring both within disciplines and with some interdisciplinary collaborations. However, it would appear that most of the interdisciplinary research conducted thus far represents multidisciplinary research where disciplines work alongside each other rather than in an integrated fashion. True interdisciplinary research requires researchers to negotiate a shared research framework for a project, evidenced by the development of terminology, research approaches, methodologies and/or theories to bridge the gaps between the disciplines (Roy *et al* 2013). The studies included in this review show no indication of integration to this extent. Given the disciplines publishing in this area are predominantly veterinary science, psychology and agricultural science which are disciplines largely underpinned by traditional reductionist science, it is possible that integration at the level described above is not required because the ontological and epistemological standpoints are shared. However, as mentioned, an opportunity exists to invite other disciplines which have different frames of reference and methodologies to join the disciplines already working in this field. Such a collaboration can be facilitated through systems thinking, and disrupting the *status quo* approaches that each disciplinary group brings creating a new approach that is irreducible to any one discipline (Rawluk *et al* 2020) that offers new insights and meaningful gains in horse welfare. For

example, undesirable horse behaviour could be examined interdisciplinarily across veterinary sciences, psychology, animal science and sociology, as well as by trainers, horse professionals and lay horse owners. This more holistic approach to horse care and training is starting to gain traction in small pockets of the lay horse community (Henderson 2020; Linton 2020; Rohlf 2020) but remains far from mainstream. Research using an integrated, interdisciplinary systems approach would provide welcome credibility and rigour to these pioneers in the lay community searching for more holistic practices and better welfare outcomes for horses (MacMynowski 2007; Bammer 2013).

From behaviour in isolation to behaviour as part of a system

As mentioned in the *Introduction*, this paper argues that keeping, training and riding horses in a manner that ensures the horse's welfare represents a complex challenge. However, the results of this review reveal that horses are yet to be studied using a framework that accounts for this complexity. Across the well-studied field of undesirable horse behaviour, all retrieved papers were based on the traditional reductionist scientific approach. Once more, crib-biting can be used as an illustration of the power of moving away from a traditional linear approach to a systems approach. Figure 4 illustrates a linear approach to the undesirable behaviour of crib-biting. In a linear model, crib-biting is the problem, therefore, any strategy which reduces or eliminates crib-biting is deemed successful. Most popular methods for addressing crib-biting include removing all furniture which the horse could use to perform the behaviour; crib-biting collars which inflict pain (punishment) whenever the horse performs the behaviour leading to a reduction in the behaviour; or surgical procedures which render the horse physically incapable of performing the behaviour (Krisová *et al* 2015). These solutions are at best crude and at worst inhumane. However, they achieve the goal, which is to stop the horse crib-biting. Both the strength and the weakness of a reductionist approach is its tendency to focus on the fine details of a problem. In terms of the complex horse-human system, reductionist thinking may lead to oversimplification and the perception of the horse as an object, an instrument of riding. Viewing crib-biting in this way allows the solutions found in the literature such as surgery and collars to appear satisfactory. A key feature of systems thinking is moving from examining objects to examining relationships (Capra & Luisi 2014). Therefore, instead of casting our gaze so close to the problem that we lose sight of the horse, if we stand back and consider the behaviour as part of a system, that is, in the context of the life of the horse, this allows the relationships and knowledge that have been hidden in plain sight to emerge (for an example of a systems diagram that puts the undesirable behaviour of crib-biting into context of the horse's life, see Figure 5. Note: this diagram does not capture all aspects of the system). This emergent, new perception of the horse and accompanying recognition that the horse's
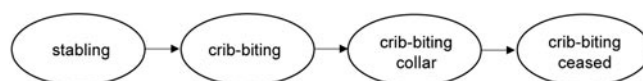
Diagram illustrating a linear approach to crib-biting in the stabled horse.

behaviour is part of a complex system creates new possibilities to disrupt the system and bring about positive change.

The crib-biting example is again useful to illustrate how a systems approach allows researchers to see old problems with new eyes. Adopting a systems approach, rather than a traditional linear approach, where crib-biting behaviour is viewed as part of the horse-human system, an altogether different goal might be set, and how crib-biting is perceived might be completely different. Re-examining Figure 5 and taking a more holistic view of the behaviour reveals that crib-biting, while related to isolation, insufficient forage and confinement, is also related to abdominal pain, aggression towards humans, horse stress levels, dressage and so on. The wide range of links to crib-biting allows interventions to become much more sophisticated and the interventions themselves can be dynamic and adapt as the system changes. Perhaps more importantly, creating a map of the system and looking at the whole life of the horse increases the likelihood that the sentience of the horse is not forgotten, and an appreciation emerges of the extent to which the horse yields its own desires to accommodate the desires of its human owner. This, in turn, is likely to change the essence of what any intervention may wish to achieve. Simply eliminating crib-biting becomes an insufficient goal. By seeing the horse as a complete living being, a more satisfactory goal emerges: to create an intervention which leads to down-regulation of the factors which stimulate the crib-biting behaviour. For example, referring back to Figure 5 and starting with crib-biting, it can be seen that crib-biting is related to isolation which is related to stress which is connected to stabling which, in turn, is related to insufficient forage and linked to ulcers. Taking all these factors into consideration, a solution to reducing or eliminating the crib-biting behaviour could include any, or all, of the following: less riding (stress reduction), turn-out on pasture or with *ad libitum* hay and a conspecific (increased socialisation and forage), dental examination (identify a potential source of pain or inadequate feed intake due to a sore mouth) and so on. For horses that crib, the motivation to crib has been shown to be equally as strong as their motivation to eat (Houpt 2012). The performance of stereotypies has also been shown to help horses cope with the stress of stabling (Briefer Freymond *et al* 2020). Therefore, it could be argued that the systems solution described above, which sees the crib-biting in context, offers a much more humane approach compared with the linear solutions such as cribbing collars or surgery.

Figure 5
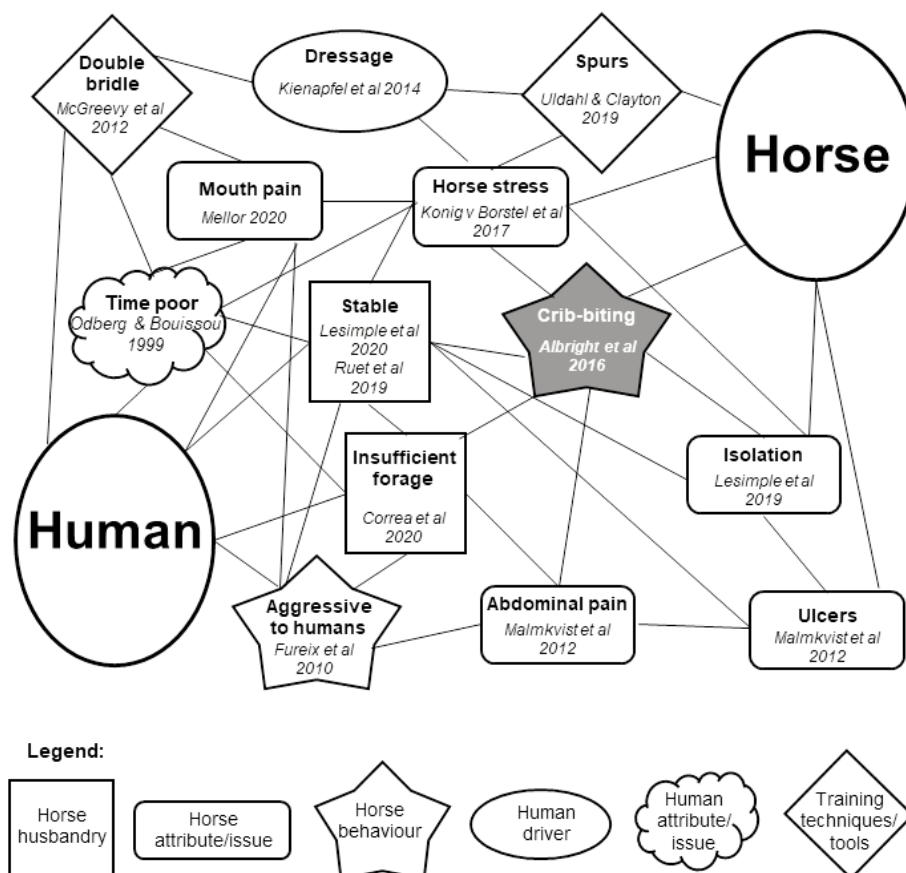
A sample systems diagram mapping some of the components and the relationships between them for a hypothetical amateur horse owner and their horse. Note: this systems map is necessarily incomplete as it is impossible to identify all components and relationships within a system.

From implicit to explicit: redefining successful practice

When shifting to a systems framework, changes in how horses and undesirable behaviours are perceived are accompanied by the recognition that relationships are dynamic and ever-changing (Greenhalgh & Papoutsi 2018). Whilst at first glance this may appear unsettling and unhelpful when solving problems, acknowledging, and embracing the dynamism and fluidity of relationships allows researchers and owners alike the freedom to adapt and tailor solutions to meet the needs of horses. Appreciating that solutions to complex problems are not 'one size fits all' and that maximising gains is an "iterative, recursive and long-term process" (Greenhalgh & Papoutsi 2018; p 3) has the effect of maintaining a wide-angle view of the system. Consider, once more, the crib-biting example, and the mechanistic crib-biting collar solution. If the collar reduces crib-biting, in a Newtonian paradigm, this strategy would be considered a success. This style of thinking is common in the management of stereotypies. One of the included studies into stereotypy found 43% of study horses were prevented from performing the behaviour by physical methods (Tadich *et al* 2013). Adopting a systems perspective and examining the horse as part of a system, rather than focusing solely on the undesirable behaviour of crib-biting,

would likely reveal some unintended consequences of inhibiting the crib-biting described above. One such consequence could be that now the horse stands in its box and nods (another form of stereotypy) or the horse enters a state of learned helplessness and just stands in its box unresponsive. Stereotypy and learned helplessness are both indicators of poor welfare (Hall *et al* 2008; Lesimple *et al* 2020). Therefore, using a systems model in this example to map the outcome of the intervention would quickly identify that preventing the crib-biting is not a success and is simply replacing one stereotypy (crib-biting) with another stereotypy (nodding) or learned helplessness. In an industry that is often seen as resistant to change (van Weeren 2008; McLean 2013) and where practices that result in negative outcomes for horses are common and often unrecognised as such (Bergmann 2020; Mellor 2020), a framework which explicates the consequences, intended and unintended, of existing practices and interventions offers a lot of promise to achieving positive change and better welfare outcomes for horses.

From 'fixing' to adaptively caring

The existing framework for managing and training horses frames undesirable horse behaviour as primarily a failing

of the horse, which causes a problem for the human and so the horse must, in a linear approach, be 'fixed' or 'cured' of this behaviour (Cooper & Mason 1998). This is consistent with society's largely unrealistic desire in general for quick fixes to often very complex problems (Straw *et al* 2019; Kalra *et al* 2020). This framing of undesirable behaviour is reflected in the types of studies being undertaken and the solutions to fix undesirable behaviour provided by science thus far (recall the surgical solution of Krisova *et al* 2015) to prevent crib-biting that was described as "the treatment of choice"). Linear-thinking approaches lead to linear solutions, which may, on face value, 'solve' the problem, but often only when viewed with a very narrow focus lens while ignoring the wider consequences of the intervention. In addition, such solutions often offer only a short-term fix, which can lead to an escalating cycle of undesirable behaviour-solution-undesirable behaviour, with solutions becoming increasingly harsh and coercive.

In contrast, a systems thinker recognises that any intervention undertaken with the hope of producing a better outcome, will have both intended consequences and unintended consequences (Greenhalgh & Papoutsi 2018). A systems thinking approach recognises the system as dynamic, and what may produce benefits today, indeed may not tomorrow (Dunn *et al* 2017). What this means is that unlike a traditional approach where a problem is fixed and then (hopefully) forgotten, in a systems approach, it is understood that ongoing, flexible adaptive care is required (Allen *et al* 2011).

Adaptive care is a cyclical process consisting of four broad steps: plan, do, monitor and learn (Webb *et al* 2018). Not to be confused with a linear thinking approach, adaptive care recognises that knowledge of the system is incomplete, much of what we think we know is actually wrong, but despite this uncertainty, planning and action is undertaken (Allen *et al* 2011). Therefore, once a system is mapped, the relationships revealed and the dynamism of the system appreciated, the next phase is to observe how the system behaves, attempt to predict future behaviour of the system and then finally, intervene in the system with the goal of achieving desired outcomes (Arnold & Wade 2017). Through maintaining a wide-view focus of the horse-human system and embracing the process of adaptive care, it is not difficult to see how solutions become individualised rather than imposed (Ellis *et al* 2017). It is also possible that in changing the perception of the horse from that of an object (instrument of riding) that needs to be fixed when it behaves badly, to part of a horse-human system that needs to be steadily managed, that the expectations of owners may also be transformed resulting in a less domination-based approach to horses. Through this repeated process of observing, trialing an intervention, observing again and finally learning from our horses, it could be that not only are better outcomes achieved, but also space is created allowing deeper relationships with horses to form, which is what many horse people seek (Birke 2008).

Animal welfare implications and conclusion

In this paper, we have argued for the need to examine the complex challenge of undesirable horse behaviour through systems thinking and have outlined the fundamentals of a systems approach: studying whole systems rather than individual parts; adopting interdisciplinarity; mapping systems to create context; examining relationships (obvious and emergent); and adopting care processes that are flexible and adaptive rather than fixes driven by linear relationships. Such an approach allows different disciplines to unite resulting in the integration of the strengths of each discipline to forge sophisticated, nuanced solutions to complex problems.

Decades of excellent science in horse behaviour and welfare has yielded an enormous knowledge bank, and yet the industry resists change, and undesirable horse behaviour, which is primarily a poor welfare signal, is still common. A systems approach does not make a complex problem simple, but it does offer a new way to conceptualise and new tools to tackle complex problems. It is hoped that reconceptualising horse-human interactions as a complex problem and highlighting a new scientific framework will stimulate discussion and scientific debate that ultimately results in the formation of new interdisciplinary teams and new research that promotes positive, healthy horse behaviour. Future studies could explore this new approach by mapping horse-human systems around particular problems and/or then using system maps to test system behaviour, followed by designing and testing system interventions predicted to lead to better welfare outcomes. There is an opportunity to bring together the wisdom of researchers, industry experts, horse training practitioners, and lay horse owners in interdisciplinary practice to form an ethically sustainable 21st century industry that centres on the horse and which will benefit both horses and humans.

Declaration of interest

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