Declaration of Bruce Nock

I, Bruce Nock, do hereby declare as follows:

1. I am a tenured neurobiologist at Washington University School of Medicine, with faculty appointments in the departments of psychiatry and neuroscience. I received a Master of Science degree from a psychobiology program at Bucknell University that focused on animal behavior and related subjects. I received a Ph.D. from Rutgers University Institute of Animal Behavior. My thesis research at Bucknell and at Rutgers focused on behavioral neuroendocrinology. In addition, I did two years of post-doctoral research in behavioral neuroendocrinology at Rutgers University and followed that with three years of research at The Rockefeller University, two as a post-doctoral fellow and one as a post-doctoral associate. During the three years at Rockefeller I worked and trained with Dr. Bruce McEwen. Dr. McEwen was a pioneer and continues to be a leading authority on stress physiology and biochemistry. My curriculum vitae is attached.

2. In 2003, I founded Liberated Horsemanship, LLC, a company which provides practical, science-based services and educational programs devoted to improving horse welfare. As part of Liberated Horsemanship’s educational services, I have published a number of articles on the negative impact of stress on captive and free roaming horses. I have also lectured numerous times on the same subject, in the United States, Australia, Canada, Italy and Spain. I have also published a peer reviewed study on the consequences of feral horse relocation with Drs. Brian Hampson and Chris Pollitt, two leading wild horse authorities.

3. My research currently focuses on epigenetic and transgenerational effects of paternal morphine or alcohol exposure. Stress physiology is a major areas of focus.
4. I am a Viet Nam veteran and served in the military from 1969–1973. During that time I held a Top Secret security clearance while assigned to a joint military command composed of Army, Navy, Air Force and Marine personnel.

5. I am familiar with the plan prepared by the United States Army Garrison, Fort Polk and endorsed by Brigadier General Gary M. Brito to "eliminate" free roaming horses from Fort Polk. I refer to this plan below as the Fort Polk plan or simply the plan.

6. Basic and necessary substantive evidence and crucial information for evaluating the potential success of the Fort Polk plan and its impact on the welfare of the horses are not included in the plan description, as discussed below.

7. The Army's plan does not include the most basic, and necessary, baseline information that is crucial for putting together a responsible horse management or horse removal plan, including a basic survey of the herds, their migration patterns, their family relationships, their encounters with humans, and basic descriptions of the types of horses living at Fort Polk.

8. The Fort Polk plan is to “adopt, give away, sell, (cyclic 4 step) and relocate” the horses. However, there is no detailed description provided for how any of these options will be implemented or the anticipated success.

9. The Bureau of Land Management (BLM) offers wild horses and burros for adoption or purchase at events across the country throughout the year. Nevertheless more than 30,000 captured wild horses continue to be maintained in holding facilities, demonstrating the supply greatly exceeds the demand. The Fort Polk plan provides no evidence indicating it will be any more successful than the BLM in its efforts to adopt/sell the horses to the general public, and given the current surplus there it is very likely that any horses gathered from Fort Polk will not be successfully adopted out or sold in the foreseeable future.
10. In our published studies of the Brumbies (wild horses) in Australia (attached), we found that the area of relocation had a significant impact on the behavior and health of the horses despite precautions to optimize the likelihood the horses would join a local herd familiar with the terrain, and the location of food and water. “Three of the four mares captured from the prime grazing habitat and released in the semi-arid desert habitat died, apparently due to stress and/or starvation, within 8 weeks of release.” The fourth mare survived only because she was recaptured and taken to a domestic care facility. The Fort Polk plan does not provide any information about where the horses will be relocated to or what provisions and precautions will be implement to assure the welfare of relocated horses.

11. Of the options under the Army’s chosen horse-elimination plan, "COA 7", sale at auction is likely to be the most used option given the current tight adoption market for wild horses. Unfortunately, it is common knowledge that many times buyers at auctions are looking for horses to be sent to slaughter. Sale at auction is often a death sentence for horses. The statement in the plan saying that COA 7 “does not involve euthanizing any horse” is technically accurate but in reality it is likely that many of the horses native to Fort Polk and obviously very important to local residents will, unfortunately, be euthanized in the end.

12. Furthermore, horse slaughterhouses are generally not allowed in the United States under a variety of state, local and federal laws and licensing programs. So horses sold to "kill buyers" are shipped to Mexico or Canada for slaughter in traumatizing and often inhumane conditions. This would be an inhumane way for the indigenous Fort Polk horses to be euthanized because, as discussed below, these horses would spend their last days in panic and trauma.
13. The Fort Polk plan provides no information about who or how the horses will be captured and handled or about where or how they will be housed or transported. There is no evidence provided that indicates that these process will be carried out by qualified individuals in a humane manner. These omissions from the plan suggest a lack of appreciation/understanding of how stressors with associated captivity can negatively impact the health and welfare of wild horses, i.e., horses that have never been trained and have always roamed freely, and horses indigenous to Fort Polk who were born there, lived there their whole lives, and have never lived anywhere else.

14. There are no good methods to capture wild horses. Even the best of the bad options will cause fear in the horses that will drive the horses indigenous to Fort Polk to resist capture without question. Capture goes against some of the most basic instincts of a species that relies on running for survival. As a result, there is serious risk of physical injury as part of this process in addition to the potential for significant psychological harm. The plan fails to include any description of the capture method. Thus, there is no way to ascertain the level of injury risk for the horses or how traumatic/stressful the process is likely to be.

15. Confinement in unfamiliar places, by penning or roping, also goes against the inherent proclivity of horses that have always roamed freely to avoid situations where the potential to flee is compromised. Then, the stressful effects of confinement are potentially compounded by social disruptions, i.e., confinement in close quarters with unfamiliar horses and the absence of life-long herd mates. Social disruption is a known, surprisingly severe stressor. And, in this case, the social disruption is likely to continue for as long as the horses live since there is no plan to release them back into their native environment, i.e., Fort Polk. Additional relocation after captivity would only add to the
problem. All-in-all, the whole process of captivity/confinelement, social disruption, and relocation, represents a severe chronic stressor, if not a trauma.

16. The deleterious consequences of such stress are not acknowledged or discussed in the plan. Without such information and a true understanding of the potentially serious consequences of stress, an objective cost-benefit analysis of the project to remove the horses from Fort Polk is impossible. The pertinent information provided below is drawn from my stress-related research which began in 1974 and from the research of a host of other scientists who collectively have published volumes of experimental findings on the negative effects of stress. The information is also supported by my background in animal behavior and years of helping people humanely train and maintain horses, including mustangs that previously roamed free in the western United States.

17. Horses, domestic and wild, are not suitable subjects for stress research. Consequently, the detrimental effects of stress can mainly be deduced from research with other species. With that in mind, experts now estimate that as much as 90% of all of our visits to primary care physicians are stress-related. Salmon age rapidly and die at first spawning due to excess stress hormone secretion. In fact, all of the available evidence indicates that stress severely impacts health and longevity throughout the animal kingdom, from fish to humans. There is no evidence to suggest horses are in any way the exception or immune to the detrimental effects of stress.

18. Stress causes extensive bodily changes that are collectively called the stress response. The stress response is identical to the fight-or-flight reaction, bodily changes designed to increase alertness, capacity for physical exertion and ability to withstand injury. To fuel this revved-up mode the body goes into metabolic overdrive. Energy stores are mobilized and nutrients are dumped into the bloodstream. The stress response/fight-or-flight reaction is designed to help an individual survive an acute physical threat. It is
not about efficiency, growth, or repair. Activating a horse’s stress response too often or for too long will lead to physical health problems.

19. At the most basic level, the stress response is inefficient. Every time it is turned on, the horse’s physiology goes into overdrive and it’s costly. The horse loses a chunk of potential energy that could be used for normal activities and for maintaining and for repairing his body. When the stress response is activated, oxygen and nutrients aren’t wasted on long-term projects, like tissue growth and repair, for example. Resources are shunted to other organs and processes that are critical for surviving the moment. Chronic stress accelerates physical deterioration. It accentuates weaknesses and turns them into pathologies.

20. Most of the harmful effects of chronic stress are attributable to overexposure to the adrenocortical hormone cortisol. Cortisol is a catabolic steroid. In contrast to anabolic steroids that promote tissue growth and get professional baseball players in trouble, catabolic steroids, like cortisol, break complex materials, like muscle and connective tissue, down.

21. One of the ways the body makes more energy available to support the stress response is to break protein down into amino acids. The liver then converts certain ones, the glucogenic amino acids, to alpha keto acids and then to glucose, the body’s main source of energy, through a process called gluconeogenesis. As a result, stress, i.e., cortisol, causes muscles to very slowly waste away through a process called catabolism.

22. Normally, the trafficking of calcium and the processes of bone formation and resorption are balanced. But stress wreaks havoc with these processes, biasing bone toward disintegration, rather than growth and repair. Part of the problem is cortisol, mobilizing calcium from bone for the good of other tissues that are more critical to surviving a threat.
23. Bone is actually a mineralized connective tissue. It is made of the same tissue, collagen, as the tendons and ligaments that surround and support it. Collagen forms a matrix. Then calcium, magnesium, and phosphate combine chemically and form into a crystalline mineral within the collagen matrix. Collagen is a protein, like muscle. And, like muscle, it is an energy source during stress. As long as cortisol levels remain high, bone mineralization and collagen formation is reduced and existing bone components are sacrificed for fuel. Supplementation with additional food, vitamin D, calcium, magnesium, etc. won’t neutralize the problem as long as the horse remains in a stress-induced catabolic state. Activate the stress response too often or for too long and it interferes with bone growth, increases susceptibility to bone injury, slows recovery from bone damage and accelerates osteoporosis. And in some cases, e.g., the coffin bone, the lost bone is not recoverable.

24. Collagen is the major form of connective tissue in the body. It makes up about 25% of the body. In addition to bone, it is a major component of tendons, ligaments, cartilage, discs, and skin. The collagen in these tissues are fuel sources during chronic stress, just like bone.

25. Digestion and appetite come to a screeching halt when the stress response is activated. Digestion is one of those processes that is shut down to conserve resources for other systems more critical for surviving an acute threat. Unfortunately, this sets the stage for colic, the number one killer of horses. It may also prevent captive wild horses from taking in sufficient nutrients to sustain their health and from adapting to the change in diet that goes along with captivity and confinement.

26. Cortisol secretion is increased by a stressful event and levels in blood remain elevated for a period of time after the stressful event ends. During this post-stress period cortisol promotes fat deposition. It is part of the recovery process. Cortisol has a somewhat contradictory effect on fat storage. It activates an enzyme called lipoprotein lipase that
stimulates fat storage, but it also increases the activity of hormone-sensitive lipase, an enzyme that breaks down fat. Normally, these effects more-or-less cancel each other out. But the insulin that is released during the post-stress period in response to excess nutrients that were dumped into the blood stream to fuel the stress response turns off the effect of cortisol on hormone-sensitive lipase. The breakdown of fat grinds to a halt. Now, the effect of cortisol on fat is to promote storage. Cortisol promotes fat storage inside the abdominal wall, around organs like the liver, heart, intestines & kidneys. It’s bad fat. Truly life-threatening. In humans and other animals and presumably horses too, it’s a risk factor for all sorts of health problems, like insulin resistance, an important risk factor for laminitis, one of the most prevalent, painful and devastating hoof pathologies in horses. Cortisol stimulates fat storage partly by promoting the release of a substance called neuropeptide Y (NPY). NPY is secreted by sympathetic nerve endings in fat tissue. And, when secreted, it facilitates the formation of new fat tissue by triggering both the formation of new fat cells, and by increasing the blood supply to the fat tissue by forming new blood vessels, a process called angiogenesis.

27. The immune system protects horses against pathogens, irritants, cellular debris and even worms. It’s a terrifically complex system of defenses comprised of some 100,000 different proteins.

28. When the stress response is activated many aspects of the immune system are enhanced. It went unnoticed for a long time because the number of antibodies in the bloodstream actually drops, suggesting a decrease in immunity. That is not the case. When the stress response is activated antibodies are dispatched to places that are prone to infection and wounding, like the skin. When they get to those places they leave the bloodstream and attach to nearby tissues and organs, and wait for a call to action. It’s called immune cell trafficking. Stressors of all types, including psychological stress, boost immune function for 30 minutes or so. But with major stressors with
longer durations immunity plummets to 40 to 70% below normal. The individual’s ability to fight off and recover from infectious diseases is compromised.

29. Another important job of the immune system is to identify and destroy tumors. The abnormal cells are destroyed by immune cells that appropriately go by the name killer T cells. But, stress decreases the number of killer T-cells in the bloodstream. Consequently, stress, even psychological stress, can markedly accelerate tumor growth.

30. Killer T-cells also help keep parasite populations under control. Consequently, a severe stressor that lasts for more than 30 minutes also compromises the individual’s ability to keep parasite populations at a level that is not harmful. Add the stress-induced decrease in killer T-cells to the shunting of resources away from long-term projects like tissue growth and repair and it spells the potential for systemic-wide tissue damage.

31. A horse’s genes are fixed. A horse is stuck with the genes he is born with whether good or bad. However, the expression of those genes, how much protein it produces, is modifiable. Changes to the microenvironment of the gene, the epigenome, can increase or decrease the expression of the gene. It can even turn the gene completely off. All sorts of things affect the epigenome, including the nature and quality of an individual’s environment and treatment, for example. The epigenome is where an individual’s genes, environment and what is done to and with the individual all come together. There is now evidence for stress-induced epigenetic changes that can last a lifetime and that may even be transmitted across generations. Stress during early development seems to be most impactful, making individuals more prone to anxiety, more reactive to stress, and more likely to show behavioral signs of depression.
Maternal separation appears to be a particularly severe stressor which has effects that last a lifetime and, importantly, are known to persist across generations. That means what we do to the horses of today may affect the welfare of generations to come. The Fort Polk COA 7 does not include any information about how the Army will prevent maternal separation or keep horse families together. This failure could have negative consequences for the health and welfare of the Fort Polk horses and their descendants.

Our cells and those of animals are constantly wearing out and getting damaged. To maintain the health and integrity of tissues, organs and structures, damaged and dying cells have to be replaced as fast as they are lost. That’s the job of cell division. However, cells can’t divide forever. There’s a limit of 50 to 75 times. That limit is set by the length of telomeres. A telomere is a region of repetitive DNA at the end of a chromosome. Telomeres protect the end of the chromosome from deterioration during cell replication. They play a critical role in determining the number of times a cell can divide and therefore how long a cell line remains viable. Each time a cell divides a portion of the telomeric DNA is lost. After 50-75 divisions, so much telomeric DNA has been lost that the aged cell stops dividing. That, in turn, affects the health of the tissue the cell forms. As more and more cells reach this stage, the tissue, organ or structure it makes up becomes less and less viable. You might think of telomeres as biological clocks that slowly rundown. A short telomere is very bad news. As an ever larger percentage of the body’s cells fail to replicate, maintenance and repair of the body becomes compromised. Telomere shortening is likely to account for most of the decline in efficiency and increases in vulnerability that go along with aging. And stress accelerates telomere shortening. This is not a minor consequence. In one study, women who were chronically stressed aged six times faster than normal. There is every reason to believe severe stress has similar effects on the telomeres of horses, thereby, accelerating deterioration and ultimately shortening a horse’s life span.
34. I have now provided only a brief overview of how the stressors associated with capture, social disruption, confinement, transport, novel environments and life in captivity might negatively impact the indigenous horses of Fort Polk. There are many other physiological processes that stress impacts. I've provided this information to highlight why information about such processes is crucial for evaluating the long term impact of removing the horses from Fort Polk. The lack of information about how such processes will be carried out suggests a total disregard for the health and welfare of the horses.

35. I understand that the presence of the horses on Fort Polk can present problems for military activities. However, it was the military's choice to establish Fort Polk in an area with free roaming horses, which they now refer to inappropriately as "trespass horses." The horses born on Fort Polk cannot legitimately be labeled "trespass" horses. It is the military that "trespassed" on their home territory. By doing so it seems to me they accepted an ethical responsibility to find a way to co-exist with the indigenous horses. The military could foster a very positive public relations image by working with locals to find a real solution for co-existence, e.g., a contraception program to slowly reduce the heard to a manageable number with a cooperative effort between the military and locals to stop further population by previously captive, i.e., authentic "trespass," horses. On the other hand, a public outcry opposed to eradicating horses that are native to the area without due consideration of its impact on local residents and the horses themselves could be very disruptive to the relationship between military personnel and the local population.


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Present Academic Position:
Associate Professor of Neurobiology, Department of Psychiatry, Washington University School of Medicine, 1992-present.
Associate Professor of Neurobiology, Department of Neuroscience, Washington University School of Medicine, 1992-present.

Education:

Undergraduate: Elizabethtown College, 1965-1969, B.A.

Graduate:

Thesis Title: Hormonal Mediation of the Effects of Defeat on Agonistic Responding in Mice.

Thesis Title: Noradrenergic Regulation of Female Sexual Behavior and Hypothalamic Steroid Receptors.

Postgraduate:


The Rockefeller University, 1982-1984, Post-doctoral Fellow, Advisor—Dr. Bruce S. McEwen.
Academic Positions Held:
Research Associate, Laboratory of Neuroendocrinology, The Rockefeller University, 1984-1985.
Assistant Professor of Neurobiology, Department of Psychiatry, Washington University School of Medicine, 1985-1992.
Assistant Professor of Neurobiology, Department of Anatomy and Neurobiology, Washington University School of Medicine, 1985-1992.
Associate Professor of Neurobiology, Department of Anatomy and Neurobiology, Washington University School of Medicine, 1992-2015.
Associate Professor of Neurobiology, Department of Psychiatry, Washington University School of Medicine, 1992-present.
Associate Professor of Neurobiology, Department of Neuroscience, Washington University School of Medicine, 2015-present.

Military Service:
United States Air Force, 1969 -1975
   Security Clearance: Top Secret
Overseas Duty:
   Guam, 1970
      Security Clearance: Secret
   DaNang, Viet Nam, 1971-1972
      Security Clearance: Secret

Academic Honors:
Alcohol, Drug Abuse, and Mental Health Administration, Research Scientist Development Award, 1991-1996.

Other Honors:

Other Positions:
Neuroscience Admissions Committee, Washington University School of Medicine, St. Louis, Missouri, 1993-1996.
National Institute of Environmental Health Sciences, Special Review Group Member, Research Funding Announcement 96-003 Endocrine Disrupting Chemicals and Women's Health Outcomes, 3/19 – 3/21/96.

Founder, Liberated Horsemanship, Warrenton, Missouri, 2004 – present.


Research Committee, Department of Psychiatry, Washington University School of Medicine, St. Louis, Missouri, Calabasas, California, 1997-2008.

Board of Directors, Association For The Advancement Of Natural Horse Care Practices, Calabasas, California, 2006-2008.


Board Member, The Captive Equine Project, Sharon Manning, 2006-present.

Wild Horse Research Coordinator, Association For The Advancement Of Natural Horse Care Practices, Calabasas, California, 2006-2008.

American Institute of Biological Sciences Panel Member for The Peer Reviewed Medical Research Program, US Army Medical Research and Materiel Command, Post-traumatic Stress Disorder, 7/12 & 7/13, 2006.

Faculty Member, The Kerulos Center, Jacksonville, Oregon, 2010 - present.

Advisory Board, American Wild Horse Preservation Campaign, Lompoc, California, 2010 - present.

Member, Equine Behavior Advisory Board, Wellington, FL, 2012 - present.

Editorial Responsibilities:
Consulting Editor, Hormones and Behavior, 1986 - 1997

Ad hoc reviewer, National Science Foundation

Ad hoc reviewer, University of Missouri

Ad hoc reviewer:
- Archives of General Psychiatry
- Brain Research
- Journal of Pharmacology and Experimental Therapeutics
- Life Sciences
- Neuroendocrinology
- Neuropsychopharmacology

Invited Lectures:
Rutgers University, Endocrinology, 1978.
Johns Hopkins University, Department of Psychology, 1982.
University of Wisconsin, Department of Biology, 1982.
Washington University School of Medicine, Department of Psychiatry, 1985.
University of Illinois, Department of Physiology and Biophysics, 1986.
Medical College of Wisconsin, Department of Pharmacology and Toxicology, 1991.
American Society for Pharmacology & Experimental Therapeutics, San Diego, California, August 17, 1991.
The Importance Of The Flight Or Fight Reaction To A Horse’s Physical And Mental Well-Being, Kentucky Equine Affaire, September, 17, 2005.
The Nature Of A True “Correction:” Dispelling The Myths Of Reprimanding Your Horse, Kentucky Equine Affaire, September, 18, 2005.
Myths and Misconceptions: The Snark is a Boojum. Symposium for the Humane and Natural Care of the Horse, hosted by Association for the Advancement of Natural Horse Care Practices, Reno, Nevada, February 25, 2008.
Wild Horses of Northern Utah, A Commentary. Symposium for the Humane and Natural Care of the Horse, hosted by Association for the Advancement of Natural Horse Care Practices, Reno, Nevada, February 26, 2008.
Science and Research. Symposium for the Humane and Natural Care of the Horse, hosted by Association for the Advancement of Natural Horse Care Practices, Reno, Nevada, February 27, 2008.
Adaptation and the Natural Hoof, Women and Horses Expo, Missouri State Fairgrounds, Sedalia, Missouri, Scheduled for October 24, 2008.
Stress and the Natural Hoof, Women and Horses Expo, Missouri State Fairgrounds, Sedalia, Missouri, Scheduled for October 25, 2008.
Developing Healthy Hooves, Naturally, Women and Horses Expo, Missouri State Fairgrounds, Sedalia, Missouri, Scheduled for October 26, 2008.
Laminitis: A Lifestyle Affliction. Equine Affaire, Columbus, Ohio, April 5 2009.
Hoof Adaptation: As I See It. Natural Hoof Care Symposium, Alessandria Italy, May 2, 2009.


Understanding Why Natural Hoof Care Works or Doesn’t Work. Equine Affaire, West Springfield, Massachusetts, November 13, 2009.


Understanding Why Natural Hoof Care Works or Doesn’t Work. Equine Affaire, Pomona, California, February 5, 2010.


Ride For Tomorrow. Presentation for the Houston Mounted Police Unit, Houston, Texas, August 20, 2010.

Ride For Tomorrow Presentation, Cat Spring, Texas, August 21, 2010.

The Sound Horse Conference, Owner’s Workshop, Louisville, Kentucky, November 4, 2010.


Horses In Captivity: Stress, Obesity And Laminitis. Australian College of Equine Podiotherapy Conference, Seymour Race Center, Seymour, Victoria, Australia, February 23, 2013.


Clinics Conducted:


Advanced Horsemanship Clinic, American Association of Natural Horse Care Practitioners, Annual Conference, Ventura, CA, March 9 & 11, 2006.

Advanced Horsemanship Clinic, Ventura, California, March 9 & 11, 2006.

Advanced Horsemanship Clinic, Warrenton, Missouri, April 22 & 23, 2006.

Advanced Horsemanship Clinic, Equestrian Center, Sharon Center, Ohio, May 5 – 7, 2006.

Liberated Horsemanship Clinic, Equestrian Center, Sharon Center, Ohio, May 6 & 7, 2006.


Liberated Horsemanship Clinic, Sharon Center, Ohio, July 21 – 23, 2006.


Liberated Horsemanship Clinic, Ashwood Farm, Wadsworth, Ohio, July 21 – 23, 2006.

Liberated Horsemanship Clinic, Cloverleaf Equestrian Center, Reno, Nevada, September 30 & October 1, 2006.

Advanced Horsemanship Clinic, Warrenton, Missouri, October 7 & 8, 2006.

Advanced Horsemanship Clinic, Warrenton, Missouri, November 4 & 5, 2006.

Advanced Horsemanship Clinic, Richfield Equestrian Center, Richfield, Ohio, November 17 – 19, 2006.

Lifeway and the Natural Hoof Clinic, Warrenton, Missouri, March 10 & 11, 2007.

Lifeway and the Natural Hoof Clinic, Warrenton, Missouri, March 16, 2007.

Lifeway and the Natural Hoof Clinic, Warrenton, Missouri, April 22 & 23, 2007.

Lifeway and the Natural Hoof Clinic, Warrenton, Missouri, June 19, 2007.

Lifeway and the Natural Hoof Clinic, Warrenton, Missouri, September 23 & 24, 2007.

Natural Horse and Hoof Care Symposium, Hosted by the Houston Mounted Police, Houston, TX, February 16, 2008.
Biology of Natural Horsemanship Symposium, Hosted by O’Neill Lawrence AANHCP CP-KY, Western Kentucky University Agricultural Center, Bowling Green, KY, March 29, 2008.


Biology of Natural Horsemanship Symposium, Hosted by Dr. Lynn O’Connor PhD, AKC Museum of the Dog, St. Louis, MO, June 14, 2008.

Biology of Natural Horsemanship Symposium, Hosted by Stacey Huntington DVM, Saddle City at PFI Western Wear, Springfield, MO, July 26, 2008.

Liberated Horsemanship Riding Clinic, Shadowbrook Stable, 4624 East Shelby Road, Fair Grove, MO, July 27, 2008.

Liberated Horsemanship Symposium, Hosted by Ann Corso AANHCP CP-KY, Best Western Parkside Inn, 80 Chenault Road, Frankfort, KY, August 8, 2008.

Liberated Horsemanship Riding Clinic, Hosted by Shelby Hume, Excelsior Farm, 3775 Old Frankfort Pike, Midway, KY, August 9, 2008.

Liberated Horsemanship Symposium, Hosted by Western Horseman Magazine Account Executive Sandy Lawson, Western Horseman Conference Room, 836 Euclid Avenue, Suite 208, Lexington, KY, August 12, 2008.

Lifeway and the Natural Hoof Clinic, Warrenton, Missouri, October 3 & 4, 2008.

Gateway to Natural Hoof Care Clinics, Warrenton, Missouri, April 17 – 22, 2009.

Gateway to Natural Hoof Care Clinics, Alessandria Italy, May 4 – 9, 2009.

Gateway to Natural Hoof Care Clinics, Lone Pine Ranch, Vernon, British Columbia, August 31 – 5, 2009.

Gateway to Natural Hoof Care Clinics, Warrenton, Missouri, October 16 – 21, 2009.

Gateway to Natural Hoof Care Clinics, Warrenton, Missouri, April 16 – 21, 2010.

Gateway to Natural Hoof Care Clinics, Warrenton, Missouri, June 18 – 23, 2010.

Ride For Tomorrow Clinic, Cat Spring, Texas, August 22, 2010.

Gateway to Natural Hoof Care Clinics, Warrenton, Missouri, October 8 – 13, 2010.

Gateway to Natural Hoof Care Clinics, Warrenton, Missouri, April 15 – 19, 2011.

Ride for Tomorrow, Riding and Training Clinic, Feather Mountain Ranch, Troy, Missouri, August 19 – 21, 2011.


The Road Map, Troy, Missouri, September 9, 2011.

The Road Map, Warrenton, Missouri, September 23, 2011.

Gateway to Natural Hoof Care Clinics, Warrenton, Missouri, September 23 – 27, 2011.

Ride for Tomorrow, Riding and Training Mini-clinic, Feather Mountain Ranch, Troy, Missouri, October 1, 2011.

The Road Map, Elsberry, Missouri, October 8, 2011.

Ride for Tomorrow, Riding and Training Mini-clinic, Double Eagle Ranch, Elsberry,
Missouri, November 12, 2011.
*The Road Map,* Troy, Missouri, February 1, 2012.
*Gateway to Natural Hoof Care Clinics,* Warrenton, Missouri, April 27 – May 2, 2012.
*Gateway to Natural Hoof Care Clinics,* Warrenton, Missouri, September 28 – October 2, 2012.
*The Road Map,* Troy, Missouri, March 8, 2013.
*Kick Start,* Texas A&M, hosted by the Parsons Mounted Cavalry, College Station, Texas, March 22 – 24, 2013.
*Gateway to Natural Hoof Care Clinics,* Warrenton, Missouri, April 19 – 23, 2013.
*Insights From World Leaders In Hoof Care,* La Llacuna, Spain, May 18 – 19, 2013.
  - Opening Remarks.
  - Inconceivable: How Suboptimal Management & Use Practices Can Undermine The Efforts of even the most skilled trimmer.
  - How stress pushes too many calories toward obesity-related pathologies and laminitis.
  - What Insulin resistance and Cushing’s disease have in common & why they are both risk factors for laminitis.
  - Obesity: The Solution Might Not Be As Straightforward As you think.
  - Protecting horses from the inherent stress of life in captivity through Environmental enrichment.
  - The impact of Biomechanics on soundness & hoof health & shape.
*Natural Hoof Care Training,* La Llacuna, Spain, May 18 – 19, 2013.
*Gateway to Natural Hoof Care Clinic,* Warrenton, Missouri, November 8 – 12, 2013.
*Gateway to Natural Hoof Care Clinic,* Warrenton, Missouri, April 25 – 29, 2014.
*Gateway to Natural Hoof Care Clinic,* La Llacuna, Catalonia, Spain, May 19 – 23, 2014.
*Gateway to Natural Hoof Care Clinic,* Ohio State University ATI, June 12 – 15, 2015.
*Gateway to Natural Hoof Care Clinic,* Ohio State University ATI, June 6 – 10, 2016.
*Gateway to Natural Hoof Can Clinic,* Ohio State University ATI, June 6 – 9, 2017.
Other Events:

2008 *Wild Horse and Burro Summit*, South Point Hotel, Las Vegas, NV, October 10 – 12, 2008.


Interviews:


Interview for *The Scientific Approach To Horse Care*. *The Horse Show with Rick Lamb*, aired March 19, 2011.


Liberated Horsemanship Sponsored Events:

*Brian Hampson Presentation*, Lake St. Louis, Missouri, October 17, 2009.


*Brian Hampson Presentation*, Sealy, Texas, August 21, 2010.


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### Published Book Chapters


### Published Books


### Other Publications


78. **Nock, B.**: Choosing A Natural Hoof Care Professional. Liberated Horsemanship Press. LiberatedHorsemanship.com, August 21, 2009.

79. **Nock, B.**: Wild Horses—The Stress of Captivity. Liberated Horsemanship Press. Commissioned by The *American Wild Horse Preservation Campaign*. LiberatedHorsemanship.com and WildHorsePreservation.com, March 16, 2010. This article was released in conjunction with “BLM Calico Complex Roundup: A Case Study of a Broken System for Horses and Taxpayers” a report by the *American Wild Horse Preservation Campaign*.


82. **Nock, B.**: *Wild Horses and Summer Stampedes* submitted by The *American Wild Horse Preservation Campaign* (AWHPC), a coalition of more than 40 public interest, historic preservation and horse advocacy organizations, as part of a complaint outlining the BLM’s negligence in the conduct of the Tuscarora roundup in northeastern Nevada. The complaint is a supplement of the ongoing Department of Interior Office of Inspector General review of the Bureau of Land Management’s wild horse and burro program, July 27, 2010.


85. **Nock, B.**: Legal declaration requested by the *American Wild Horse Preservation Campaign* and the Washington, DC-based public interest law firm Meyer, Glitzenstein and Crystal. The declaration supports a law suit, case number 1:11-cv-01352-ABJ, that seeks to block the U.S. Department of the Interior’s Bureau of Land Management from implementing an unprecedented plan that initiates the destruction of two wild horse populations in southwestern Wyoming.


94. Nock, B.: Legal declaration requested by the Wildlife Law Program/Friends of Animals. The declaration supports a law suit (Case Number 1:15-cv-01500-CRC) that seeks to block the U.S. Department of the Interior’s Bureau of Land Management from using helicopter drive trapping to remove all of the wild horses from the West Douglas Herd Area, and potentially remove some horses from the East Douglas-Piceance Basin Herd Management Area of Colorado.


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Health and behaviour consequences of feral horse relocation

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Abstract. Despite ongoing projects involving the breeding and release of equids into semi-wild and wild environments, insufficient information is available in the literature that describes strategies used by equids to adapt and survive in a novel environment. The aim of this study was to assess the ability of naïve, feral \textit{Equus caballus} (horse) mares to cope in a novel feral horse environment and investigate possible reasons why some may not survive this challenge. Four mares taken from a semi-arid desert environment remained in good health but significantly changed their movement behaviour pattern when surrounded by prime grazing habitat in a mesic temperate grassland. Three of the four mares captured from the prime grazing habitat and released in the semi-arid desert habitat died, apparently due to stress and/or starvation, within 8 weeks of release. The fourth mare survived 4 months but lost considerable weight.

The group of mares relocated to the semi-arid desert environment had difficulty adapting to relocation and did not take up the movement behaviour strategy of local horses, which required long distance treks from a central water hole to distant feeding areas at least 15 km away. The movement behaviour, range use and health consequences of relocating equids may be of interest to wildlife ecologists, animal behaviourists and horse welfare groups. The observations may be used to guide those intending on relocating managed domestic and native horses to novel habitats.

Additional keywords: equine, GPS, movement, range.

Introduction

Several equid species are at risk of extinction worldwide (Boyd et al. 1988; Van Dierendonck et al. 1996) and as a result wild equid behaviour has attracted a volley of research over the past 40 years (Feist and McCullough 1976; Linklater 2000; Cameron et al. 2009). Information about equid behaviour has been useful in developing breeding programs under semi-natural social conditions (Houpert and Fraser 1988; Scheibe et al. 1998). Threatened wild equid species, such as Przewalski horses (\textit{Equus przewalskii}) and Asiatic wild asses (\textit{Equus hemionus}) have been raised in captivity in an attempt to preserve the species and subsequently reintroduced into native conditions to strengthen herd numbers in at-risk populations.

Managed breeding programs followed by release into wild environments have had mixed results. Przewalski horses were extinct in the wild in the 1960s and were bred in captivity and released into a natural wild habitat in Mongolia in 1997 (Bahloul et al. 2001). Approximately one-third of the released Przewalski horses perished within the first 3 years of release (Robert et al. 2005). Horses died from a tick-transmitted disease, wolf predation, \textit{Streptococcus equi equi} infection (strangles), trauma, exhaustion, wasting, urolithiasis, pneumonia, abortion and stillbirth (Robert et al. 2005). Another study group of Przewalski horses was reintroduced from a captive breeding program in 1992 with a positive population development. However, in winter 2009–10 ~65% of the population perished due to severe winter snow storms (Kaczensky et al. 2010). The effect of an unprotected environment and removal of human intervention may have been underestimated in these cases and animals may not have been sufficiently prepared for the release. Further study of equid behaviour in novel habitats is clearly warranted.

This study aimed to assess the ability of naïve mares to cope in a novel feral horse environment and investigate possible mechanisms that describe how equids cope with this challenge. The use of Global Positioning Systems (GPS) made it possible to quantify diurnal movement behaviour for long time periods. For this initial study, we utilised feral horses exclusively to avoid the difficulties encountered by others (Bahloul et al. 2001; Robert et al. 2005) who released horses raised in captivity. We anticipated feral horses to be more adaptable and less at risk when released in a novel environment.

The range use and health consequences of relocating mares may be of interest to wildlife ecologists, animal behaviourists and welfare groups. The observations may help guide those intending to relocate managed domestic and native horses to novel habitats.

Materials and methods

\textit{Animals and location}

The study was performed with feral horses from two different areas of Australia. One study area was Mt Tabor (lat. 26.41, long.
This area is on the fringe of prime cattle breeding country in the Warrego region of central-west Queensland. The area is heavily timbered with *Eucalyptus crebra*, commonly known as the Narrow-leaved ironbark and *Callitris columellaris* (White cyrus pine) and is largely made up of light sandy soils. Black spear grass (*Heteropogon contortus*) is predominant, with only small areas of improved pastures in open country (IBIS 2006). Mean annual rainfall for the area is 528.5 mm (Bureau of Meteorology, Australia; www.bom.gov.au) and is evenly distributed throughout the year. Mean annual maximum and minimum temperatures are 28.0 and 13.5 °C, respectively. Data from adjacent weather stations reports an annual mean solar exposure of ~21 MJ/m² (Bureau of Meteorology, Australia). The location had a large body of pasture in all areas during the study period, including areas within 200 m of the permanent water sources. Permanent water consists of man-made dams located at ~10-km intervals throughout the 50 000-ha paddock. Terrain is undulant and consists of small valleys and open woodland flats rising to mountain peaks of moderate height (Fig. 1a, b).

The second study area (Fig. 2a, b), Petermann Valley (lat. 24.50, long. 132.10), is a 2 000 000-ha semi-arid desert area in the south-west corner of the Northern Territory, consisting of a valley system bordered by high, prominent escarpments. The area is diverse topographically with elevations ranging from 600 to 800 m. Dominant trees are mulga (*Acacia aneura*) and ironwood (*Acacia estrophiata*) with river gum (*Eucalyptus camaldulensis*) growing along dry river courses (IBIS 2006). Native perennial and annual grasses are scarce due to high competition for food between feral cattle (*Bos primigenius*), horses (*Equus caballus*) and camels (*Camelus dromedarius*). Vegetation was particularly scarce within 15 km of the single, permanent spring-fed water hole. Feral horses in this area walk up to 65 km from water to find food (Berman 1991) in the form of pasture and browse. Mean annual rainfall is 335 mm (Bureau of Meteorology, Australia), which occurs sporadically over the summer months. From 2002 to 2009 drought conditions prevailed; mean annual rainfall was 219 mm (Bureau of Meteorology, Australia). Climatic conditions vary from hot summers, where maximum temperatures regularly exceed 40 °C, to winter frosts at night. Mean annual maximum temperatures are 30.6 and mean annual minimum temperatures are 15.8 °C (Bureau of Meteorology, Australia). The annual mean solar exposure is 22 MJ/m².

Capture, handling and release

Four adult mares from each study area (*n* = 8) were the subjects of this study. Each horse was darted with 0.7 mL of the immobilising agent etorphine hydrochloride (Imobilon, Novartis SA Pty Ltd, Johannesburg, South Africa) as they approached water. After the...
horse became recumbent, it was haltered and revived by administering 1.4 mL diprenorphine hydrochloride (Reviron, Novartis SA Pty Ltd) intravenously.

The horses were maintained in captivity for 2 weeks. During this period the horses were kept together in a 1-ha paddock. They were fed grass, hay and water ad libitum. During the 2-week period, each horse was handled daily to allow handlers to lead and trailer load the horses with reasonable safety.

After 2 weeks, horses were transported by trailer to one of the study areas. Horses were photographed from the side and from behind before release. The photographs were subsequently used to determine body condition score (BCS), which was used as an indicator of health. BCS was graded according to a standardised algorithm was developed by the team’s software engineer (DZ) to assess each GPS fix precision and its location in relation to its nearest collected coordinates. First all fixes with a horizontal dilution of precision (DOP) greater than 8 were removed from further processing. DOP specifies the effect of GPS satellite geometry on GPS precision and is calculated by the GPS unit for each fix taken. When the DOP value is high (more than 10) acquired satellites are close together and the geometry is weak. Therefore, the acquired coordinates are encumbered with relatively large error. In contrast, when the DOP value is low (less than 8), acquired satellites are far apart and the geometry is strong, enabling more accurate GPS readings. Removing all the fixes with DOP greater than 8 gave assurance that all the remaining data was acquired with high precision.

In the second step of the process each fix was assessed to determine if its location was in harmony with its neighbouring location fixes and all fixes not in harmony were removed from the data. In simplification, this method looked at the horse movement pattern and eliminated irregular points to smooth the travelling line plotted between the groups of related coordinates.

This project was approved by the University of Queensland Animal Ethics Committee, which monitors compliance with the Animal Welfare Act (2001) (www.legislation.qld.gov.au/LEGISLTN/CURRENT/A/AnimalCaPrA01.pdf) and The Code of Practice for the care and use of animals for scientific purposes (approval number SVS/64908/AHF). Travel permits between studies areas were obtained and horse health checks were performed before horses crossing state borders in accordance to stock movement requirements. Horses were treated for cattle tick infection when appropriate and clearing certificates were obtained for movement across tick infection zone boundaries.

Results

Prime to semi-arid group

Due to intermittent functioning of VHF location beacons on the horses the planned observations of horse health within the first week of release, in accordance with ethical approval, did not occur. Three of the four mares relocated to the Petermann Valley area were found dead during the health check at 8 weeks following release. The cause of death was assumed to be starvation although the horses were released after being fitted with a collar containing a GPS data logger and a very high frequency (VHF) beacon (four at Petermann Valley and two at Mt Tabor). Two horses were released at Mt Tabor without a GPS collar due to insufficient collar numbers. The horses from Mt Tabor were released in the Petermann Valley area (prime to semi-arid group). The horses from the Petermann Valley were released in the Mt Tabor area (semi-arid to prime group).

Several precautions were taken before and after release to aid the adaptation and survival of the horses. In particular, all mares were familiarised with the water source before release. In addition, all mares were released either individually with an existing horse band in sight, or in the company of other study horses. We attempted to locate horses within the first week of release to perform health checks. Finally, although the study period was planned to continue for 4 months (see below), horses were observed 8 weeks after release to assess health and body condition.

Healthy horses were recaptured 4 months following release to recover GPS collars. Relocation of horses was achieved by a combination of surveillance of water holes at regular intervals and VHF receiver monitoring. Horses were recaptured by the same darting method described for the original capture and transported to the university stock facility for complete health checks.

GPS monitoring of movement and position

One Sirtrak (Sirtrak Ltd, Havelock North, New Zealand) and five kedzig (Kedzig Innovation Group, Mannsville, NY, USA) GPS animal tracking collars were programmed to fix position data points at 7- and 3-min intervals, respectively. The range use and maximum daily distance that horses travelled away from water sources was determined from GPS data locations. Watering frequency was determined by the frequency that horses came within close range of known water point positions. The pattern of travel was also superimposed on Google Earth satellite photographs (Google Earth Plus, http://earth.google.com/enterprise/earth_plus.html, accessed July 2010) and checked for plausibility and location data error. A GPS error detection algorithm was developed by the team’s software engineer (DZ) to assess each GPS fix precision and its location in relation to its nearest collected coordinates. First all fixes with a horizontal
(Fig. 4). The mean watering frequency for Christine was 1.04 per day.

NO4 (GPS #2). This mare was found dead during the health check at 8 weeks following release. The movement sensor on GPS #2 confirmed that the mare had died 6 weeks following release. Her carcass was found 3 km from the only existing water hole. During the 6 weeks NO4 mare made only two treks out from water in the first and second week of the study (Fig. 3b). In the first week she travelled 10 km in a north-west direction towards the common feeding areas for local feral horses, which were 15 km away in that direction but did not reach them. She returned to the water hole for 3 days and attempted another trip 12 km from water in the opposite direction without reaching the feeding areas 15 km away. During the second trip she stayed without water for 7 days before returning to the familiar spring. She then remained close to water for the remaining 4 weeks until her death. The mean watering frequency of NO4 was 1.28 per day.

Limo (GPS #3). The mare remained with the NO4 (GPS #2) mare for the first 6 days but was separated on day 7. Her GPS malfunctioned on day 8. Limo was found dead during the health check at 8 weeks after release in close proximity (2 km) of the water hole. The time of her death is unknown. However, according to the state of carcass decomposition Limo and Morgan (GPS #4) died at approximately the same time. The GPS data (Fig. 3c) collected for 7 consecutive days indicate mean watering frequency of 1.43 per day for this mare.

Morgan (GPS #4). The carcass was found 15 km from the water hole during the health check at 8 weeks following release. Her GPS malfunctioned and no data was recoverable.

The three active GPS data loggers confirmed that collectively, prime to semi-arid group mares watered at a mean frequency of 1.25 times daily (Table 2). The maximum daily distance moved away from water for each mare is illustrated in Fig. 3a–c. The movement behaviour of this group of mares suggests that they did not access outlying food sources sufficiently often to stay alive. Mares remained close to the water source, but due to overgrazing by other animals, insufficient food was available.

Semi-arid to prime group

All four mares improved in condition and were found in good health 8 weeks following release. All mares were observed to be living within two local feral horse bands during weekly observations by a station hand. Three mares: Priscilla (GPS #5), Alice (GPS #6) and Blondie were part of a large harem band containing a stallion, six mares and their offspring. As three of the four subject mares were located in the same band for the study period, the GPS #5-derived movement pattern of Priscilla was taken as representative of all three mares. Alice (GPS #6) was not wearing her GPS collar when relocated. The fourth mare (Bonnie) was transient between this band and another smaller band, but was regularly observed within the same area as Priscilla. The movement pattern of this mare was also taken to be similar to GPS #5. At 4 months after release all mares were in the same bands as at 2 months after release. All of the semi-arid to prime group mares had improved BCS by at least 1 score point (Table 1) and appeared to have integrated well into existing social structures of the local feral horses.

Priscilla (GPS #5). The GPS unit provided good data from 23 days at 3-min intervals. Priscilla watered with a mean frequency of 1.9 times daily. The maximum daily distance travelled from water for this mare is illustrated in Fig. 3d and shows that she remained in close proximity (range 0–4.9 km) of the two available water points for the duration of the study. Food was plentiful within a radius of 200 m of the water points. The mare regularly moved between the two water points which were located at opposite ends of the home range.

Discussion

This study assessed the ability of naïve, feral mares to cope with relocation from their native habitat to a different habitat where other feral horses live. Three of the four mares relocated from a prime grazing habitat to a semi-arid desert habitat were found dead at the health check which was conducted halfway through the study period, i.e. 8 weeks following release. This was unexpected because this habitat sustains thousands of healthy, native feral horses. Conversely, mares taken from the semi-arid habitat to the prime grazing environment 3000 km away integrated into existing social groups and improved in condition over the 4-month period of the study. The use of GPS gave the present study the unique ability to quantify diurnal movement behaviour for long periods of time. This data gave plausible explanations not previously reported, for the poor health consequences of relocating equids into a novel environment.

Horses are thought to be adaptable to the environment in which they find themselves (Kiley-Worthington 1990). It has been reported that horses placed into a new environment inhabited by other equids create new bonds with other, unfamiliar horses (Budiansky 1997). The present study assumed that subject mares would be accustomed to the necessary survival strategies and typical social structure of equids and would integrate well into the social and behavioural system of the host feral horse population, irrespective of habitat. This assumption proposed that the introduced horses would join up with host harem bands, and be led by knowledgeable matriarchic mares in a pattern of survival for that environment. This assumption was correct for mares introduced from a semi-arid environment into the prime grazing environment. In contrast the mares from a prime grazing environment, when introduced into a semi-arid environment, did not integrate. These horses may have lacked the physiological adaptation and conditioning of local horses that was necessary for survival.

Table 1. Body condition scores (BCS) for all animals before (PRE) and after (POST) the 4-month habitat swap period

<table>
<thead>
<tr>
<th></th>
<th>Prime to semi-arid</th>
<th>Semi-arid to prime</th>
</tr>
</thead>
<tbody>
<tr>
<td>BCS PRE</td>
<td>BCS POST</td>
<td></td>
</tr>
<tr>
<td>Christine</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>NO4</td>
<td>4</td>
<td>Dead</td>
</tr>
<tr>
<td>Limo</td>
<td>4</td>
<td>Dead</td>
</tr>
<tr>
<td>Morgan</td>
<td>4</td>
<td>Dead</td>
</tr>
<tr>
<td>Priscilla</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Alice</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Blondie</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Bonnie</td>
<td>3</td>
<td>5</td>
</tr>
</tbody>
</table>
Fig. 3. (a) Maximum daily distance from water by GPS #1 (Christine) for the duration of GPS tracking. The maximum distance from water was 10.0 km over 116 days; (b) maximum daily distance from water by GPS #2 (NO4) for the duration of GPS tracking. The maximum distance from water was 11.9 km over 42 days; (c) maximum daily distance from water by GPS #3 (Limo) for the duration of GPS tracking. The maximum distance from water was 10.4 km over 7 days; (d) maximum daily distance travelled from the two available water points by the semi-arid to prime group mare GPS #5 (Priscilla) for the duration of GPS tracking. This mare was never more than 4.9 km from an available water source.
GPS tracking indicated that horses introduced into the semi-arid habitat remained very close to the water source for the majority of the study period. We propose that this flawed movement strategy was the most likely cause of death. It appeared from the observed movement patterns that they did not integrate with local horse bands and subsequently did not benefit from local knowledge and survival strategies. Berman (1991) observed feral horses at the same study location feeding at distances of 65 km from the water source. Hampson et al. (2010) using GPS data loggers, reported that horses using this water source sought feed up to 55 km away. The typical survival strategy for the local horses was to walk out to distant feeding areas after drinking (Hampson et al. 2010). The naïve, introduced horses did not consistently follow this pattern. It is thought that equine individuals are heavily reliant on strong social systems for survival (Waran 1997; Linklater 2000). Important survival information, such as location of feeding grounds and water points, may be passed from one generation to another (Maloiy 1970). Therefore, animals released from domestic or semi-feral breeding programs may not be sufficiently socially adapted or possess the knowledge and skills required for survival in a harsh novel environment, where local knowledge is critical. Studies of managed domestic horses deprived of their familiar equine companions and placed into an unfamiliar environment have shown that social integration may take up to several weeks (Budiansky 1997; Sondergaard and Turner 2008). An extended period of social isolation from locally adapted horses may have been responsible for the poor survival of some of the introduced horses in the present study.

A second possible cause of failure of the horses introduced into the semi-arid environment is an inability to cope physiologically. Even though we introduced feral horses from an alternative-free roaming environment, these horses may not have been able to cope with the physiological demands required for desert survival and socialisation into local herds. Hampson et al. (2010) reported that desert horses watered at 2–4-day intervals, depending on the distance to their feeding areas. Scheibe et al. (1998) found that Przewalski horses drank less frequently than domestic horses and drank a higher volume of water relative to body size. They suggested that drinking frequency was not as important to wild horses as the amount of water consumed. These authors, as well as Bouman and Bouman (1994) and Sneddon et al. (1991) suggested that African desert-dwelling horses were genetically adapted to hot dry climates as part of the evolutionary strategy of the species. Other equid species have apparently also adapted to

### Table 2. The mean daily watering frequency of prime to semi-arid group mares and semi-arid to prime group mare for the duration of GPS tracking

<table>
<thead>
<tr>
<th>Prime to semi-arid group</th>
<th>Semi-arid to prime group</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS #1 (Christine)</td>
<td>GPS #2 (NO4)</td>
</tr>
<tr>
<td>116 days</td>
<td>42 days</td>
</tr>
<tr>
<td>1.04</td>
<td>1.28</td>
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<table>
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<tr>
<th></th>
<th>GPS #3 (Limo)</th>
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<tbody>
<tr>
<td>GPS #4 (Priscilla)</td>
<td>7 days</td>
</tr>
<tr>
<td>GPS #4</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
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<td></td>
<td>1.25</td>
</tr>
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<td></td>
<td>1.9</td>
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</table>

Fig. 4. Range use of the prime to semi-arid introduced horses. The home range (5460 ha) of three introduced study mares is outlined in aqua. Two of the mares spent all of their recorded time in this area. One mare (GPS #1) made two trips outside the home range, which are marked in red and blue. This mare survived 116 days in the desert. Typical food locations (green markers) and paths to these locations (white) taken by local horses are illustrated. These data indicate that introduced mares did not follow the typical paths of local horses to access outlying feeding areas. Instead, introduced horses remained close to the water source. Three of the four mares died within 8 weeks of release.
arid conditions. Maloiy (1970) subjected Somali donkeys (*Equus asinus*) to heat stress and dehydration. Donkeys survived water loss equivalent to 30% of their original bodyweight in temperatures up to 40°C and survived up to 12 days without water. Donkeys were able to drink in 2–5 min enough water (24–30 L) to restore the deficit. Maloiy (1970) concluded that these observations represented a thermal and metabolic adaptation of desert mammals to heat and aridity. The population of desert horses in the present study may also be physiologically adapted, enabling them to travel long distances and withstand long periods without water and thus survive in competitive, semi-arid conditions. Feral horses relocated from the less extreme habitat may not have possessed the ability to endure long walks to feeding areas. Nor may they have been able to withstand the short-term dehydration consequences of making the long treks to feeding areas. The introduced mares made few treks to feeding areas during the study period. Christine, the surviving mare, made only two treks to the remote feeding areas in the last 5 weeks of the study period and spent the majority of that time close to the water hole. This may have been a consequence of exhaustion caused by enduring unaccustomed exercise and periods of dehydration. It may also have been a factor preventing the mare integrating socially with local herds. Excluded from resident bands and without the benefit of local knowledge the introduced mares may have been ‘lost’. Failure to be guided to and from feeding grounds by resident ἀ-mares and/or stallions exposed the introduced mares to starvation. Semi-arid mares relocated to prime grazing country were able to remain within close distance of the water source as there was plentiful food available. Had survival in this habitat required long treks from water to food areas, these mares too may have been challenged to survive. Perhaps the equine memory is underestimated. Horses travelling all their lives, from birth to adulthood, in familiar terrain along well used pads, would be unlikely to get lost and starve. If the introduced mares had integrated readily into existing local bands they may have all survived. When relocated horses fail to thrive the impact of social factors should not be discounted.

Kaczensky et al. (2010) reported that severe environmental conditions caused the death of 65% of the reintroduced Przewalski horse population in the 2009–10 Mongolian winter. Of the surviving population 80% were born locally in the Takhin Tal study area and the Gobi desert. Only 20% of surviving horses came from managed breeding programs in zoos in Europe (Kaczensky et al. 2010). It may be that locally bred horses had physiological or social advantages over the introduced horses that allowed them better survival mechanisms and strategies in the extreme conditions encountered.

In a previous study, feral equids exploited all food available in a new environment (Van Dierendonck et al. 1996). In the present study, introduced mares appeared to integrate well with existing social bands in the prime grazing country only. The desert horses introduced to this new habitat were presumably adapted to a desert survival strategy of long walks to food grounds with infrequent watering periods. However, these horses changed their feeding and watering habits in keeping with local feral horses. Introduced horses watered once or twice daily and never moved more than 4.9 km away from the water sources. Water and food was abundant in this environment. The observed watering and feeding pattern is in keeping with observations of domestic horses kept in large paddocks and Przewalski horses kept in semi-reserve conditions (Scheibe et al. 1998). These horses have been observed to drink several times daily. Scheibe et al. (1998) suggested that the high water consumption of confined horses may be a learned behaviour acquired under conditions of abundance.

The change in watering and feeding pattern of the desert horses introduced to the prime grazing habitat suggests that the range-use pattern observed in the desert horses by previous authors (Berman 1991; Hampson et al. 2010) may be an adaptation to an extreme environment rather than a pattern which is natural for equids. While desert horses may travel long distances to food and water at intervals of up to 4 days, given the opportunity of more abundant food and water, they adopted a less extreme, easier use of their range. This may be an important observation of equine ecology.

Despite the fact that some data were missing due to GPS malfunction, the information gathered provided interesting and useful reference data. The high degree of matching obtained between comparable datasets shows good registration of diurnal movement patterns that related to the ability of introduced feral horse mares to cope with new environments. Although the outcome of this study was tragic, with the death of three of the eight subject horses, it serves as a test case for the ability of introduced horses to cope in a novel environment. We found that even feral horses were unable to successfully cope when released into a habitat which was harsher than their native environment.

The present study urges thoughtful consideration when introducing equids into a new environment, particularly into the semi-arid conditions which wild and feral equids often inhabit. Due to malfunctioning of VHF relocation equipment we were unable to perform regular health checks on all released animals. This was in contradiction to our ethical advice. The lack of health checks on the arid-zone animals until 8 weeks after release was far too long. Had we been able to perform health checks on all horses at the end of the first release week, the outcome of the study may have been more desirable. We recommend that future researchers take further steps to ensure that all guidelines of animal ethics committees are able to be fulfilled, particularly in situations when the safety of animals may be compromised. We acknowledge the suggestion that behavioural changes are often the first and the most obvious sign of an animal coping with its environment (Fraser and Broom 1997). Further studies similar to the current project should consider close and regular monitoring of behavioural changes that herald stress and the inability to cope. A thorough general health and physical assessment, including cardiovascular fitness and foot health, should form part of the pre-release health check. Health, demeanour and body condition should be assessed at regular intervals and animals must be promptly withdrawn and rehabilitated if they deteriorate. Candidates for release should be confined in the company of a feral band to ensure, as far as practicable, that integration occurs. This study showed that leaving band assimilation to chance can have fatal consequences. We have consulted with our animal ethics committee following the death of the experimental animals, and believe that the publishing of the present study, along with improvements discussed with our animal ethics committee, will improve the ethics approval system in the future.
Acknowledgements

We believe that further research is required to assess the behavioural and health consequences of relocating equids into new and challenging environments. This will allow for strategies to be developed to safeguard equids from the potentially serious health consequences of reintroduction and relocation.

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