Applied Animal Behaviour Science 130 (2011) 91–100

Contents lists available at ScienceDirect

Applied Animal Behaviour Science

journal homepage: www.elsevier.com/locate/applanim

Preference and demand for exercise in stabled horses

Joyce Lee[a], Toby Floyd[b], Hollis Erb[b], Katherine Houpt[c,*]

[a] Animal Surgical and Emergency Center, 1535 South Sepulveda Boulevard, Los Angeles, CA 90025-3311, USA
[b] Department of Population Medicine and Diagnostic Services, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853, USA
[c] Department of Clinical Sciences, College of Veterinary Medicine, Cornell University, Ithaca, NY 14853, USA

ARTICLE INFO

Article history:
Accepted 3 January 2011
Available online 2 February 2011

Keywords:
Horse
Welfare
Exercise
Operant conditioning
Two choice preference
Treadmill

ABSTRACT

Operant conditioning and two choice preference tests were used to assess the motivation of horses to be released from straight and from box stalls. The motivations for food, a companion, and release into a paddock were compared when the horses had to work for each commodity at increasing fixed ratios of responses (panel presses) to reward in an equine operant conditioning stall. The motivation for food (mean ± SEM = 258 ± 143) responses was much greater than that for either release (38 ± 32) from a straight stall into a large paddock alone or into a small paddock with another horse (95 ± 41) ($P = 0.04$). When given a two choice preference test between exercise on a treadmill for 20 min or returning to their box stalls, eight of nine horses chose to return to their stalls. In a two choice preference test six of eight horses in box stalls chose to be released into a paddock alone. Horses were given a series of two choice preference tests to determine how long they preferred to be in a paddock. After 15 min in the paddock the horses were re-tested, but all chose the paddock when released into a paddock with three other horses. They were retested every 15 min until they chose to return to their stalls. They chose to stay out for 35 ± 6 min when other horses were in the paddock but for only 17 ± 2 min when they would be alone. When deprived of stall release for 48 h the horses chose to remain in the paddock with other horses for 54 ± 6 min, but showed no compensatory behavior when they were alone (duration chosen = 16 ± 4 min). These findings indicate that horses are not strongly motivated to exercise alone and will choose not to endure forced exercise on a treadmill. The social context of voluntary exercise is important; horses are willing to stay out of their stalls longer if other horses are present and will show compensatory behavior only if other horses are present. These finding have implications for optimizing turnout time for stalled horses.

© 2011 Elsevier B.V. All rights reserved.

1. Introduction

Feral and wild horse live in bands and spend most of their time grazing or resting (Boyd and Bandi, 2002; Duncan, 1980; Salter and Hudson, 1979). Grazing consists of taking a few bites of grass before walking a few steps to a new feeding station. Walking comprises 3–10% of free ranging horses' time and trotting or cantering less than 1%. In contrast to the environment of free ranging horses, that of most recreational and performance horses is a stall with limited opportunity for exercise. Denial of freedom of movement (exercise) has been raised as a welfare issue by several authors (Cooper and Albentosa, 2005; Fraser and Broom, 1990; Goodwin, 2002).

Consideration of the exercise requirements of horses is important for several reasons: (1) controversies should be resolved scientifically. For example, the welfare of mares used in estrogen production who may be confined for 6 months of the year with access to a paddock only once every

* Corresponding author at: 3065 East Dixon Lake Road, Gaylord, MI 49735, USA. Tel.: +1 989 448 8083.
E-mail address: kah3@cornell.edu (K. Houpt).

0168-1591/$ – see front matter © 2011 Elsevier B.V. All rights reserved.
doi:10.1016/j.applanim.2011.01.001

two weeks was questioned; (2) formulation of recommendations by governmental and professional organizations should be based on objective criteria; (3) the welfare of horses owned by private individuals, the vast majority of horses, needs to be addressed. The objective of this study was to determine horses' motivation and preference for exercise – both spontaneous and forced exercise. Patterson et al. (2008) have noted that operant conditioning techniques have not been applied to equine welfare. We hoped to begin filling that experimental void in our knowledge of equine welfare.

We had four distinct questions: (1) whether the horse is motivated to obtain exercise; (2) whether it has a preference between exercise and stall rest; (3) how strong is its motivation to exercise, and (4) whether the preference for exercise is altered by deprivation or a change in the social environment.

Operant conditioning can measure and rank the strength of preferences, whereas choice tests allow comparison of situations, but not quantification of rank. In order to measure motivation we applied operant conditioning and progressive ratios of reinforcement to evaluate the strength of the preference for food, companionship, and release from a straight stall (Hodos, 1961). Several studies have found that horses readily solve simple two choice mazes (Haag et al., 1980; Kratzer et al., 1977), so we used that method of determining preferences. Horses housed in box stalls were used to test their preference for forced (treadmill) exercise over returning to their stall. Repeated two choice preference tests were used to determine how long a horse preferred to be in a paddock either alone or in a small group. Finally, the issue of whether the motivation for exercise in a paddock increases with deprivation – compensatory or rebound behavior – was addressed by comparing the duration horses chose to be in a paddock following 48 h of confinement to their stalls.

This study was approved by the Institutional Animal Care and Use Committee of Cornell University.

2. Materials and methods

2.1. Motivation for release from stall

2.1.1. Animals, housing, and management

Nine mares (six thoroughbreds and one each quarter horse, Arabian, and Arabian-quarter horse cross) of median age 14 years (range 10–19) were used. They were housed in a barn that was arranged with one pipe rail straight stall (2.3 m × 1.0 m). A box stall (3.6 m × 3.6 m) was located in the barn to house the companion horse. Pine shavings were used for bedding in the straight and box stall and both were cleaned out at 07:00 and 17:00 h. The horses were fed *ad libitum* non-legume hay. In addition, 0.7 kg of a 15% protein textured horse feed (Legends® Agway Inc., Syracuse, NY, USA) was also provided twice a day. A salt block was available. Water was available at all times, via buckets in the straight stall and an automatic waterer in the box stall.

2.1.2. Apparatus

The operant conditioning arrangement consisted of a 10 cm × 10 cm metal plate attached by a hinge to an electrical junction box that was affixed to the upper left hand corner of the inside of the front door of the straight stall. When pushed by the horse, a small switch with a spring lever located in the box beneath the push plate was closed, completing a 24 V circuit to an electronic counter (Biomedical Electronics, Cornell University, Ithaca, NY, USA). This counter could be preset to a specific number.

Repeated pushes by the horse were counted down from the preset number until zero was reached, and then a relay was automatically closed that completed a circuit to the solenoid of the latch mechanism of the door. At that time, the door latch unlocked with an audible click and the door swung open, allowing access to a small paddock (100 m^2) (used for food and companionship) that adjoined a larger paddock. The total area available to the horses in both paddocks was 917 m^2 (used for release).

Except for the 30-min test period, a wooden chest guard made from a 0.51 cm × 1.02 cm piece of wood with a hasp locking mechanism that attached to the pipe railing was placed across the straight stall in front of the panel so that the horse could not reach it and exit the stall when not in testing condition. There were two horses that required restraint while they were housed in the straight stall. They were restrained with an elastic, quick release tie rope so they would not be able to escape under the rails. Both horses had enough slack on the rope to be able to eat, but not enough to escape by ducking under the side rails.

A metal gate and a garage door separated the barn from the paddock. When the garage door was open the horse was able to look out into the small paddock.

2.1.3. Operant training

Each horse was familiarized with exiting the experimental stall by walking through it and into the paddock two or three times. The next step was to shape the behavior of pressing the panel with the nose. To accomplish this, clicker training was employed, although recently Williams et al. (2004) have found no advantage in speed of learning using this method. While the horse was in the straight stall, a clicker would be clicked a few times and the horse would receive a small grain reward with each click. This was done so the horse associated the sound of the clicker (secondary reinforcer) with a reward (primary reinforcer). Once the horse paired the sound of a click with food, the investigator would then click and reward only if the horse's nose was within a 15 cm radius of the panel. Through successive approximation, the horse would only be rewarded when she touched the panel. Once she associated pushing the panel with her nose with a reward, the next step was to chain the whole set of behaviors together (pushing the panel then walking out into the paddock for a reward). To start chaining the behaviors together, the electronic counter was set to FR (fixed ratio) = 1. The horse was rewarded only when she pushed once on the panel and then walked out into the paddock. This was repeated several times at FR = 1. Then, the FR would be set at 2, and again, the horse would be rewarded only when she completed two pushes and walked out into the paddock. The time in the paddock was the same as the time used as a reward

during testing-either 30 min (large reward) or 5 min (small reward).

The training was repeated at FR = 2 and at FR = 4. When the horse was releasing herself from the straight stall each day, the experiment was begun. Overall, this shaping took an average of three days to complete. Each training session was limited to 20 min/day (Appendix B).

The experiment was conducted using two schedules (daily and multiple times/day increase in FR for a large and small reward, respectively). In the large reward schedule, the horse worked for a higher FR each day until she no longer completed the number of responses needed for a reward (extinguished). This ratio was increased each day the horse successfully obtained release from the straight stall. Each trial had a time limit of 30 min. After initial operant training, the horse began working for one of three rewards: 30 min in large paddock; 0.7 kg of grain (Agway Legends®, Agway, Inc., Westfield, MA, USA); or 30 min in a small paddock with a companion horse. If the horse did not accomplish release for the day under the time limit (30 min), the same ratio would be used the next day. Again, if the horse did not obtain release, the ratio was reduced to what it was 3 days prior. If she did not get out, she would be considered to have extinguished and the ratio would be the largest number of responses she successfully made.

Two different progressive ratios (PR) were used in the large reward schedule. Initially, two horses were tested using a doubling progressive ratio (3, 6, 12, 24, etc.). Due to the large increase in the required response between trials, which may have resulted in failure to reach the FR, a less rapidly increasing progressive ratio (1, 2, 4, 7, 11, etc.) was used for the three subsequent mares.

When working for release from confinement, the horse would have 30 min to complete the preset FR for the day. If she pressed the allotted number of times, the door latch would release and she would get 30 min in the paddock. After 30 min, she was returned to the straight stall. The next part of the experiment used food as motivation. The set up was the same as release motivation, but hay and grain were withheld in the mornings. The testing for food (0.68 kg of grain) occurred at around 09:00 h. When the experiment started, the bucket of grain was shown to the horse so she could see and smell the grain. Then the bucket was placed outside in the small paddock after the gate was opened. The horse had 30 min to eat the grain and remain in the paddock. The third reward was companionship. Another horse was procured and acclimated to the living in an adjacent box stall to the straight stall. For the experiment, the companion horse was placed in the small paddock and the experimental horse would be allowed to work for release to be with the companion horse for 30 min.

The testing phase took 3 weeks. Each day for 1 week the horse would be required to push the panel a certain numbers of times for the reward. The number of responses required rose each day according to the progressive rate. The time limit to complete each FR was 30 min. If the horse did not succeed in pressing the correct amount of times within the time allotment for the reward, the horse would not be released from the straight stall for the day. The same FR would be repeated the following day. After 7 days of working for one of the rewards, the horse would have another 7 days to work, under the same conditions, for another reward. The following 7 days was for the third reward.

Three horses of the five original horses plus three new horses were tested using a modified protocol, the small reward schedule. The small reward schedule was essentially the same as the large reward schedule, but the rewards were smaller, 46 g of food, 3 min with a companion and 3 min in the large paddock In the small reward schedule, the mares worked for as many small rewards as she could earn on the same day, each time for a higher FR (according to the progressive ratio schedule 1, 2, 4, 7, 11, etc.) until she failed to gain access within the trial time (extinguished). The experiment was divided into two phases – a training phase and a testing phase. During the training phase, the horse was given the opportunity to work for 7 days for each of the three rewards. The three rewards were randomized and blocked so that two of the six horses began with food, two with release and two with companionship.

Once the horse completed 21 days of training, the testing phase began in which the motivation of the horse was tested on days 22, 23, and 24 (each day for a different reward) to determine the highest number of responses (when motivation would extinguish) for each of the three rewards. The order of the rewards on the test day was similar to the order used while training. The testing was similar to the training and the progressive ratio (1, 2, 4, 7, 11, etc.), but the horse would be continuously tested until she stopped working for the particular reward. The time limit to complete each FR was 20 min. For food reward, once the horse finished 46 g of food, she would be returned to the straight stall to work again for release for food (46 g). Both release and companionship was limited to 3 min in the paddock with one of the two rewards.

2.1.4. Statistical analysis

Nonparametric statistical analysis was used. The highest ratios reached, blocked by horse, were compared to determine if there were any statistically significant differences using a nonparametric ANOVA (Friedman). The data were analyzed using the computer program, Statistix (Statistix, 1996, Analytical Software, Tallahassee, FL, USA). The first part of the analysis determined whether there is a difference between all three treatments using a P value of 0.10. In the case of significant differences, a Wilcoxon Signed Rank Test (Wilcoxon Signed Rank Test, Wilcoxon Research, Inc., Germantown, MD, USA) was used to determine which pairs of rewards (release versus food, release versus companionship, and food versus companionship) were different. Because there were multiple comparisons made between the pairs, the P value ($P = 0.03$) was adjusted to reflect a Bonferroni's correction. Elasticity of demand could not be calculated for all the horses, but the log of the consumption rate (rewards/h) was plotted against the log of the fixed ratio for the two horses for which data were available.

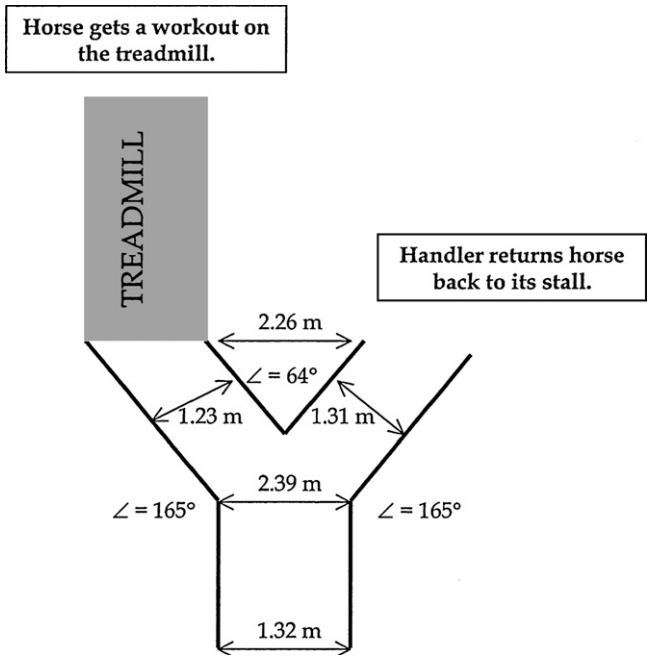

Fig. 1. Diagram of maze used to test preference for treadmill exercise.

2.2. Preference for treadmill exercise

2.2.1. Animals and management

Nine horses (five standardbreds, three thoroughbreds and an Arabian/quarter horse cross; five geldings and four mares) (median age = 5 yr, range 3–15 yr) were used in this experiment. The horses were housed in box stalls. They were bedded on straw and fed approximately 9 kg mixed Timothy hay and 2–3 kg mixed grain ration for exercising horses. Water was supplied in buckets. The horses had been conditioned and exercised on a high-speed treadmill (Sato Model 1, Sato Treadmill AB, Uppsala, Sweden).

2.2.2. Treadmill

A Y maze was built to use at the treadmill. It consisted of three movable pieces (Fig. 1). Each piece consisted of a rectangular frame (1.22 m × 2.14 m) with diagonal crossbars. Blue plastic sheeting covered the frames. Two of these frames were connected via hinges to make one piece. Another (0.51 cm × 1.02 cm) piece of wood was cut to provide stabilization to these pieces and secured to the frames with bolts. Due to the position of the treadmill, it was not possible to control for side preferences. The horses turned left to enter the treadmill and right to return to their stalls.

All horses used in this experiment went through a training phase where they learned the significance of each arm of the Y maze. The training phase consisted of alternating days on which the horse was led through the left arm to the treadmill, where the horse exercised, with days on which the horse was led through the right arm to return to the stall with no exercise for the day. A coin toss, on the first day of training, determined which side the horse would be led through first. By the end of the training phase, each horse had experienced 5 days of going left to the treadmill and 5 days of going right to its stall.

In the first 5 days of the training phase, the horses were led from their stalls to the building housing the treadmill (Equine Performance Laboratory, Cornell University, Ithaca, NY, USA). The horses were led to the entrance of the Y maze. They were allowed to smell and explore the entrance of the maze. Then, they were walked through one arm, as dictated by the coin toss. If the arm was the treadmill, they were exercised. The exercise was either jogging for 4800 m or jogging for 4000 m and galloping for 1200 m depending on the day of the week. Each exercise bout was preceded and followed by walking 400 m on the treadmill.

The next day, the horse was brought back to the maze and led through the opposite arm. This was continued for a total of 5 days. At the end of 5 days, the horse would be released in the entrance of the maze with people standing in the exit arms of the maze. The horse was given some freedom to walk in the maze, but was not allowed to enter the wrong arm of the maze. This was continued for the remaining 5 days.

2.2.3. Testing preference for treadmill exercise

The test phase was conducted over 3 consecutive days. To avoid influencing the direction taken by the horse, the handler from outside the maze held the horse from in front by both sides of its halter in the middle of the entrance to the maze and then released the animal. Two other people stood at the far ends of the maze to catch the horse after it had made a decision. This was repeated on 2 more testing days.

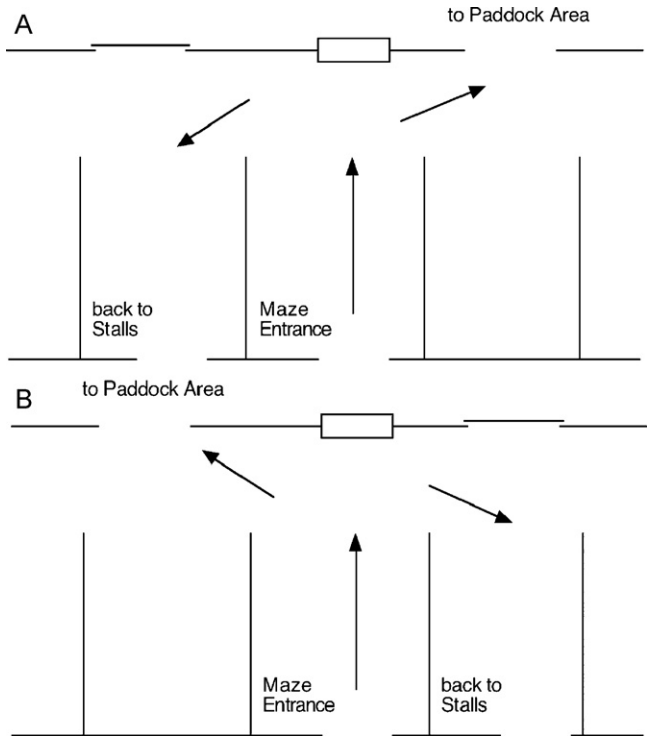

Fig. 2. Diagram of maze used to test preference for release into paddock. (A) Right turn to enter paddock; left turn to return to stall. (B) Left turn to enter paddock; right turn to return to stall.

2.2.4. Statistical analysis

The data were analyzed using confidence limits for proportions (Beyer, 1968). Since the horses were given three opportunities to choose which arm of the maze they wanted to enter, a method was devised to assign a choice value based on the decision the horses made that could be analyzed. If the horse chose to return to its stall twice or more during the testing period, then the horse was assigned as stall for analytical purposes. A horse was assigned treadmill if it chose to exercise twice or more. Based on this, proportions were calculated for each reward (stall or treadmill), and 95% confidence limits were obtained.

2.3. Preference for release from box stall

2.3.1. Animals, management, and facilities

Seven non-pregnant mares and one gelding (four thoroughbreds, two Trakehners, one Arabian, one thoroughbred cross and one Trakehner cross) (median age = 11.5 yr) were used for this experiment. The horses had free access to water (by bucket) and lucerne hay. Each horse was groomed once every 2 days.

The horses were housed in box stalls for the duration of the study. Three stalls were 5.2 m × 3.7 m and five were 5.2 m × 2.0 m. The front walls were 1.3 m and the intervening walls 1.7 m in height, allowing full visual, auditory, and olfactory contact and limited tactile contact between horses in neighboring stalls. Each stall also had a window. Wood shavings were provided as bedding and each stall was cleaned once a day.

The paddock provided for exercise was 21 m × 25 m. It consisted mainly of bare earth with little vegetation. Buildings bounded it on three sides but there was no other shelter. Horses in other paddocks were visible but could not be contacted directly.

2.3.2. Maze

A simple two-choice maze was improvised from a set of disused stalls as described in Fig. 2. It was designed so that horses could directly access either the stalls or the paddock depending on the direction they took (left or right).

For each of the three studies the horses were divided into two groups: a left group (L) and a right group (R). Horses of the left group were given access to the yard if they turned to the left and were returned to their stalls if they went to the right. Those in the right group were given access to the yard when they turned right and returned to their stalls if they turned left in the maze.

2.3.3. Preference for release in a group for 30 min

Access to the paddock in this study involved a period of 30 min, which commenced from the moment the final horse in that group had exited the maze, for both the training and trial periods. During the training period the horses spent time in the paddock as a whole group of four, whereas, during the trials only the horses that chose to access the yard were present in it.

2.3.4. Training

The horses were trained over a period of 10 days. On days 1–5, the horses were led through the maze three times

Table 1
The highest FR reached by each horse for each reward.

Horse	Large release	Large food	Large companionship	Small release	Small food	Small companionship
Alexis	211	326	326	232	704	211
Natasher	37	742	742	2	904	254
Sasha	22	46	22	0	4	4
Sunny				11	16	7
Cool front				4	56	16
Gabrielle				1	92	4
Melody				16	29	29
Spice	12	96	12			
Shandy	137	191	56			

to the right and twice to the left with the appropriate result of either release into a paddock or returning to their stalls. For example, on day 1 all horses were lead through the maze to the right so that those in the R group went to the yard and those of the L group went back to their stalls. On days 6–10 the horses were not led but forced to take a direction by blocking the opposite path with a gate, twice to the right and three times to the left. Thus each horse had five sessions in which it returned to its stall and five in which it entered the paddock.

2.3.5. Testing

After the 10-day training period, three trials were conducted over 3 days. The L and R groups were tested separately to avoid aggression in the paddock. Each horse was given free choice to turn left or right. The order within their group in which horses were both trained and tested was randomized. For each trial with each horse the direction taken (and consequence) was recorded.

2.3.6. Statistical analysis

Significance in this case has been determined by the means of the trial groups lying outside the confidence intervals of the other groups (see Dawson-Saunders and Trapp, 1994).

2.4. Preference for duration of release and compensation for deprivation

2.4.1. Animals, management, and facilities

The horses and facilities were those used in the preceding experiment.

2.4.2. Duration of release training

The training period was longer than for the preference for release study, but followed a similar procedure. On days 1–12, only the horses that were going out that day were lead through the maze: i.e. one group per day. On days 13 and 14 each group was led through the maze to the left and right so that all the horses experienced accessing the yard and returning to their stalls. On days 15–22, all horses of each group were not led but forced through the maze by a gate a total of four times in each direction. During the training period each group was allowed to remain in the paddock for 30 min. Additional training was given for days 23, 24, 25 and 26. During this period, the horses were given a free choice of turning left or right. All the horses chose to go out the first time and after 15 min were brought back in and forced to the opposite side and so back to their stalls. Each horse of both groups was allowed to go out on all 4 days.

2.4.3. Duration of release testing

During the test period of 6 days the horses were given free choice to turn left or right. They were tested on 4 of the 6 days. Each group was again tested together. If a horse chose to enter the yard, then 15 min after that horse accessed the yard it was removed and brought back to the maze entrance to be re-tested. Any horses in the yard remained there during the process. If it again chose to access the yard it was re-tested again after 15 min and so forth. If the horse chose, in any test, to return to its stall it was not re-tested that day. The period of time spent in the paddock was recorded for each horse in each trial. There was a space of 2 days between trials 3 and 4 where all the horses were confined to their stalls. Therefore, the final test measured response to deprivation of exercise.

For the solitary release condition, each horse was tested once per day individually for 3 days, rested in its stall for 2 days and tested again. The horse was allowed access to the yard while the other horses remained in their stalls. As in the group release condition after 15 min in the yard the horse was removed to the maze entrance and re-tested. Again, if the horse chose to return to its stall it was not re-tested that day. The length of time spent in the paddock by each horse for each trial was recorded.

2.4.4. Statistical analysis

Significance in this case has been determined by the means of the trial groups lying outside the confidence intervals of the other groups (see Dawson-Saunders and Trapp, 1994).

3. Results

3.1. Motivation for release

See Table 1. The median highest responses for a large reward were 37 for release, 191 for food, and 56 for companionship. There was a significant difference in the mares' motivations for release, food, or companionship (Friedman statistic = 7.625, df = 2,8, $P = 0.02$). To distinguish if the differences between each reward were significant, the Wilcoxon Signed Rank Test was conducted for each possible pairing of the rewards, and using a P value that reflected a Bonferroni adjustment ($P = 0.03$). There

Table 2
The choices made by stalled horse to enter a paddock containing other horses or return to their stalls.

Horse	Trial 1	Trial 2	Trial 3
1	Paddock	Paddock	Paddock
2	Paddock	Paddock	Paddock
3	Paddock	Paddock	Paddock
4	Stall	Stall	Stall
5	Paddock	Paddock	Paddock
6	Stall	Stall	Paddock
7	Paddock	Paddock	Paddock
8	Paddock	Paddock	Paddock

were no significant differences between food and release companionship and food, and companionship and release (Wilcoxon Signed Rank Test, $n = 5$, $P < 0.06$).

The median highest number of responses for a small reward was 4 for release, 56 for food, and 16 for companionship (Friedman statistic = 9.53, df = 2,12, $P < 0.001$). There was a significant difference in motivation between food and companionship (Wilcoxon Rank Sign Test median difference = 40, sum of positive ranks = 15, sum of negative ranks = 0, $P = 0.059$) and between food and release (Wilcoxon Rank Sign Test median difference = 5.2, sum of positive ranks = 0, sum of negative ranks = 28, $P < 0.02$). There was no significant difference between release and companionship (Wilcoxon Rank Sign Test median difference = 169, sum of positive ranks = 0, sum of negative ranks = 210, $P > 0.05$). The log of the consumption rate (rewards/h) plotted against the log of the fixed ratio for one horse – Spice – is presented. See Fig. 3(A). The equation of the line for food calculated by least squares is $Y = 2.0338 - 0.79762\ X$, indicating an inelastic demand. The equation of the line for exercise is $Y = 2.4467 - 3.5556\ X$. The equation of the line for companionship is $Y = 2.4981 - 1.1085\ X$. The log of the consumption rate (rewards/h) plotted against the log of the fixed ratio was also plotted for a second horse – Shandy. See Fig. 3(B). The equation was $Y = 2.53 - 0.69\ X$ for food; the equation of the line for exercise was $Y = 1.95 - 0.57\ X$. The equation for companionship was $Y = 1.17 + 0.093\ X$. These were the only two horses for which information other than highest ratio reached was available.

3.2. Preference for treadmill exercise

In the forced exercise preference study, eight out of nine horses (89% of the horses) chose to return to their stalls in three out of three trials. One horse (out of nine) chose to exercise on the treadmill two out of three trials. For statistical purposes, that horse was treated as a horse that preferentially chose to exercise (11% of the horses). The confidence limit values for horses that chose to exercise ranged from 1 to 47%, with our value of 11% falling within the 95% limits ($P < 0.05$). Conversely, the 95% confidence limits for horses that chose not to exercise (return to their stalls) ranged from 53 to 83%. The confidence ranges are wide due to the small sample size ($n = 9$).

3.3. Preference for release from box stall

The selection for exercise (paddock) or stall for the eight horses in the three trials appears in Table 2. As can been seen, most of the horses chose to enter the paddock while horse #4 preferred to return to its stall in all three trials and horse #6 preferred to return to its stall in the first two but not the third trial. The mean number of trials in which the horses chose to enter the paddock was 2.7 ± 0.4. The preference to exercise was significant (95% confidence interval, $n = 8$, $P < 0.05$).

3.4. Preference for duration of release and compensation for deprivation

The mean amount of time spent in the paddock, as a group and as an individual (per day per horse) was described using a 95% confidence interval (see Table 3). The minimum and maximum time periods spent in the paddock, by any given horse, each day are also included in Table 3. There was a significant difference between the mean time spent in the paddock when released in groups (34.9 ± 6.1 min) and when released alone (16.7 ± 2.1 min, 95% confidence interval, $n = 8$, $P < 0.05$). There was also a significant increase in the duration preferred by horses after two days of exercise deprivation (53.4 ± 6.0, 95% confidence interval, $n = 8$, $P < 0.05$), but only when the horses were released in groups. Significance in this case was determined by the means of the trial groups lying outside the confidence intervals of the other groups.

4. Discussion

We obtained answers to our four questions: Horses are motivated to obtain exercise, but it is an elastic demand. The highest ratio of responses to reward was always that for food. The horses definitely preferred not to exercise at speed based on the choice of eight of nine horses to avoid 20 min of treadmill exercise. Horses prefer stall rest to forced exercise, but prefer release from their stalls for voluntary exercise for at least 15 min; the preference for free movement by stabled horses is readily demonstrated by the results of the preference for release studies; in 19

Table 3
Duration of turnout chosen by horses alone and in a group daily or after deprivation.

	Min turnout	Max turnout	Mean turnout	St. dev.	95% Confidence interval
Group release					
Daily release	15	67	34.9	17.13	27.64 < tm < 42.11
48 h Deprivation	33	69	53.4	17.26	38.94 < tm < 67.81
Solitary release					
Daily release	15	33	16.7	5.79	14.22 < tm < 19.11
48 h Deprivation	0	31	15.9	11.58	6.19 < tm < 25.56

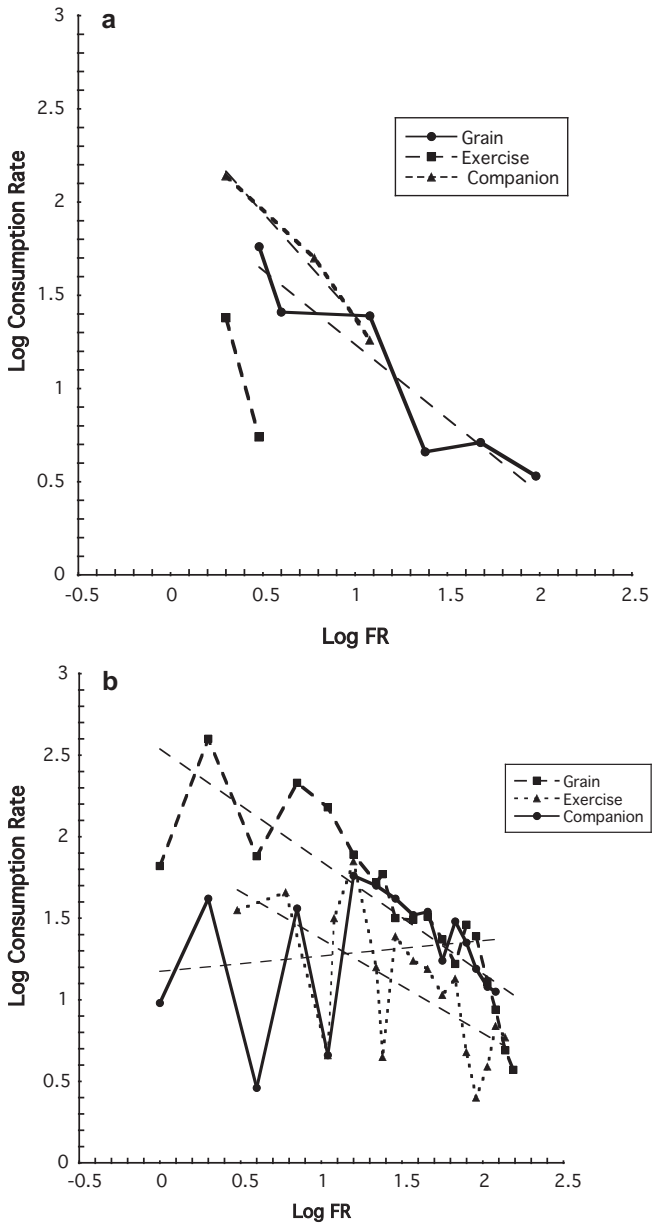

Fig. 3. The demand function for the three commodities: exercise, a companion horse, and food. Consumption rate is rewards/h. The least squares method was used to calculate the lines that are represented by the light gray dashed lines. (A) Demand functions generated by horse Spice. (B) Demand functions generated by horse Shandy.

out of 24 two choice trials the horses preferred to spend time in a paddock. The preference for exercise is altered by deprivation in that a longer duration of exercise is preferred after deprivation. The social situation influences preference in that horse turned out alone prefer to remain outside for a shorter period and do not show compensation for deprivation.

The length of time horse chose to remain in a paddock varies with the social situation. When part of a group of four horses they chose to spend 42–278 min in the paddock. In contrast, when in the paddock alone they chose to spend 17 min. Even more interesting is that deprivation of release for 2 days increased the time horses chose to spend in a group but not the time that it spent alone. This interaction of social and movement preferences is not surprising is a species that lives in bands and should be borne in mind when designing equine facilities and making recommendations for their welfare.

The initial motivation for the operant conditioning study was to determine the welfare of mares used for estrogen production, PMU (pregnant mare urine). These mares are confined in tie stalls without the ability to

turn around and with only limited release. Several studies have indicated that those mares apparently are not stressed behaviorally or physiologically by those conditions (Freeman et al., 1999; McDonnell et al., 1999), but do show compensatory movement when released after 2 weeks confinement (Houpt et al., 2001). When confined in a stall similar to those used in the PMU industry, mares did not seem highly motivated to be released. This study indicates that exercise is not a highly motivated behavior, but also indicates that horses do show compensatory behavior in that they prefer to be out in a paddock longer if they have been deprived of exercise for as little as 2 days.

The demand for stall release as a "commodity" appears to be elastic in that horses will work much harder for food than for release even from a narrow stall. Dawkins in her original paper (1983) on consumer demand as a measure of welfare compared time spent by hens with food versus litter. She concluded, "When food is the reward animals appear to work harder for the same amount of reward. Food thus shows inelastic demand". In the present study horses initially (FR1) worked harder for food than for other commodities and, when the amount of work necessary for the reward increased, their rate of consumption did not fall as fast as that for exercise or the company of another horse.

There are, of course, many difficulties in interpretation. For example, if we had confined the horses for longer periods or fasted the horses for a shorter period would they have been willing to work harder for release than for food? The type of food used as a reward also matters; Ninomiya et al. (2007) have shown that horses can learn an operant task for a food reward and their performance varies with the palatability of the food. They used FR1 and found that the horse earned more rewards for pelleted feed than for timothy hay earning 100 rewards of pellets and 50 rewards of hay. If we had allowed 60 min of release as a reward would this have changed the outcome? Another complication is that the food reward was an open environment because the horses received food at times other than in the operant condition. The release and companionship rewards were in a closed environment; they did not have access to these outside the operant condition (Ladewig et al., 1992). Finally, breed, sex, life history, and husbandry factors such as the human–animal relationships can affect the horse's motivation. The horses in this experiment were adults. Their rearing conditions could have been particular with, for example, specific human–animal relationship that could have affected the motivation of the horses for exercise. Good human–animal relationship could motivate the horses when poor ones could decrease this motivation.

It is interesting that those horses that worked for both large and small rewards showed the same general pattern of responding. Two horses were willing to press many times, as many as 904 presses, for the rewards, and the third was much less willing to work. Although Natasher and Alexis worked equally hard for food and companionship when the rewards were large, they worked much less for companionship when the reward was small. Five min with a companion may not be very valuable, but a mouthful of grain is. Another explanation is that the reward is consumed before the horse must return to her stall, but the companion remains. The separation from the companion may be aversive to the horse.

The horses did not avail themselves of the opportunity to exercise on the treadmill. The horse could be objecting to the lack of resiliency in the substrate of the treadmill, to the speed and duration of the exercise, or to the animal's complete lack of control over its movement. In an earlier study of exercising horses we found that after exercise for 30 min on the same treadmill the horses drank more immediately afterward and lay down more, indicating that they were thirsty and tired (Caanitz et al., 1991). It would be interesting to determine if horses would also choose to avoid being ridden, driven or free lunged (round pen training).

The horses used in the motivation for release experiment were an average of 14 years old; different results might have been obtained if younger horses had been used, presupposing that younger horses prefer more exercise. The behavior of free ranging horse indicates that there are large sex differences in locomotion. While subadult colts trot and canter more than adult mares, subadult fillies do not (Duncan, 1980). Our results from older horses are applicable to many equine disciplines because dressage and even jumping horse are well into their teens before their performance peaks. The results are even more applicable to companion horses because many are ridden into their twenties and kept for their life span that is approaching thirty years as medical care and management of older horses improves.

Eating, drinking, sleeping, copulation, grooming, play, social interaction and locomotion are all recognized 'drive-motivated' behaviors (Dellmeier, 1989). That is, they are behaviors for which the motivation will increase in the absence of performing them. Cooper and Albentosa (2005) reviewed equine behavior and welfare and mentioned exercise as a requirement for good welfare.

Our results suggest that the motivation for locomotor behavior increased over the 2 days of stall confinement indicating voluntary exercise is drive-motivated. The investigations of Dellmeier et al. (1985) of confined calves and Taylor and Friend (1987) on crated sows as well as those of Houpt et al. (2001) and Mal et al. (1991) of horses also agree with these results.

The published duration of stall release (exercise) requirements for horses is 30 min (Consortium, 1988). This is approximately what we found horses preferred if they were released in a group. They preferred shorter duration when alone in a paddock. These results should be considered when managing horses.

5. Conclusion

Rather than suggest that horses that are turned out alone need less time in the paddock, the results of this experiment show the benefit of exercising horses in groups, especially where the paddock groups are composed of socially compatible horses. What is the ecological need for exercise? To try the answer this question we measured the strength of preferences for three commodities and found that horses will not work as hard for the opportunity to exercise as for palatable food. The finding that horses do not prefer forced exercise is not surprising because mov-

ing at a gait faster than a walk is predator defense and, although it occurs in nature, it is a better indicator of poor than of good welfare.

Acknowledgements

We are grateful to Dr. Norman Ducharme and the Equine Performance Laboratory staff for use of the treadmill and their horses and to Charles Houpt for technical assistance.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.applanim.2011.01.001.

References

Beyer, M.R., 1968. CRC Handbook Table of Probabilities and Statistics, 2nd ed. CRC Press, Boca Raton, FL, USA.

Boyd, L., Bandi, N., 2002. Reintroduction of takhi, *Equus ferus przewalskii*, to Hustai National Park, Mongolia: time budget and synchrony of activity pre- and post-release. Appl. Anim. Behav. Sci. 78, 87–102.

Caanitz, H., O'Leary, L., Houpt, K., Petersson, K., Hintz, H., 1991. Effects of exercise on equine behavior. Appl. Anim. Behav. Sci. 31, 1–12.

Consortium for Developing a Guide for the S Care and Use of Agricultural Animals in Agricultural Research and Teaching, 1988. Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching. Agricultural Animal Care Guide. Division of Agriculture, National Association of State Universities and Land-Grant Colleges, Washington, DC, USA.

Cooper, J.J., Albentosa, M.J., 2005. Equine behaviour and welfare. In: McDonnell, S.M., Mills, D.S. (Eds.), The Domestic Horse: The Evolution, Development and Management of Its Behavior. Cambridge University Press, Cambridge UK, pp. 228–238.

Dawkins, M.S., 1983. Battery hens name their price: consumer demand theory and the measurement of ethological "needs". Anim. Behav. 31, 1195–1205.

Dawson-Saunders, B., Trapp, R.G., 1994. Section 7.4.1. Confidence Intervals for the Difference Between Independent Means, Chapter 7, Estimating and Comparing Means. Basic and Clinical Biostatistics, 2nd ed. Appleton and Lange, East Norwalk, CT, USA.

Dellmeier, G.R., 1989. Motivation in relation to the welfare of enclosed livestock. Appl. Anim. Behav. Sci. 22, 129–138.

Dellmeier, G.R., Friend, T.H., Gbur, E.E., 1985. Comparison of four methods of calf confinement. II. Behaviour. J. Anim. Sci. 60, 1102–1109.

Duncan, P., 1980. Time budgets of Camargue horses. II. Time budgets of adult horses and weaned sub-adults. Behaviour 72, 26–49.

Fraser, A.F., Broom, D.M., 1990. Farm Animal Behaviour and Welfare. Baillière Tindall, London, UK, 118.

Freeman, D.A., Cymbaluk, N.F., Schott, H.C., Hinchcliff, K., McDonnell, S.M., Kyle, B., 1999. Clinical, biochemical, and hygiene assessment of stabled horses provided continuous or intermittent access to drinking water. Am. J. Vet. Res. 60, 1445–1450.

Goodwin, D., 2002. Horse behaviour: evolution, domestication, and feralisation. In: Waran, N. (Ed.), The Welfare of Horses. Kluver Academic Publishers, Boston, MA, USA, pp. 1–18.

Haag, E.L., Rudman, R., Houpt, K.A., 1980. Avoidance, maze learning, and social dominance in ponies. J. Anim. Sci. 50, 329–335.

Hodos, W., 1961. Progressive ratio as a measure of reward strength. Science 134, 943–944.

Houpt, K.A., Houpt, T.R., Johnson, J.L., Erb, H.N., Yeon, S.C., 2001. The effect of exercise deprivation on the behaviour and physiology of straight stall confined pregnant mares. Anim. Welfare 10, 257–267.

Kratzer, D.D., Netherland, W.M., Pulse, R.E., Baker, J.P., 1977. Maze learning in quarter horses. J. Anim. Sci. 46, 896–902.

Ladewig, J., Sorenson, D.B., Nielsen, P.P., Matthews, L.R., 1992. The quantitative measurement of motivation: generation of demand functions under open versus closed economies. Appl. Anim. Behav. Sci. 79, 325–331.

Mal, M.E., Friend, T.H., Lay, D.C., Vogelsand, S.G., Jenkins, O.C., 1991. Physiological response of mares to short term confinement and social isolation. Eq. Vet. Sci 11, 96–102.

McDonnell, S.M., Freeman, D.A., Cymbaluk, N.F., Schott, H.C., Hinchcliff, K., Kyle, B., 1999. Behavior of stabled horses provided continuous or intermittent access to drinking water. Am. J. Vet. Res. 60, 1451–1456.

Ninomiya, S., Mitsumasu, T., Aoyama, M., Kusunose, R., 2007. A note on the effect of a palatable food reward on operant conditioning in horses. Appl. Anim. Behav. Sci. 108, 342–347.

Patterson, E.G., Pittman, M., Pajor, E.A., 2008. Operant animal welfare: productive approaches and persistent difficulties. Anim. Welfare 17, 139–148.

Salter, R.E., Hudson, R.J., 1979. Feeding ecology of feral horses in western Alberta. J. Range Manage. 32, 221–225.

Taylor, L., Friend, T.H., 1987. Effect of housing on open field test behavior of gilts. Appl. Anim. Behav. Sci. 17, 83–93.

Williams, J.L., Friend, T.H., Neville, C.H., Archer, G., 2004. The efficacy of a secondary reinforcer (clicker) during acquisition and extinction of an operant task in horses. Appl. Anim. Behav. Sci. 88, 331–341.