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Novel objects placed in feeder increase the feeding time of foals fed concentrate feed

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ABSTRACT. This study aimed to evaluate the feeding time and reactivity of male and female foals exposed to novel objects (seven plastic balls measuring 8 cm in diameter) placed inside the feeder. Eleven mixed-breed foals (males = 6; 316 ± 42 kg of BW, females = 5; 290 ± 35 kg of BW) were used. The amount of concentrate feed was calculated using 2000 g kg^{-1} BW for males and 1500 g kg^{-1} BW for females. Behavioral variables were assessed using a scoring system. Data on time spent feeding were subjected to analysis of variance and regression analysis ($p < 0.05$) and compared using the PROC REG procedure of SAS (with object = without object). A line of equality ($y = x$) was used to test correlations. The behavioral model was fitted by a generalized linear model using the GLIMMIX procedure of SAS, and means were compared ($p < 0.05$) by *t*-tests. Feeding time differed between sexes (males = 23.7 ± 4.8 min., females = 19.5 ± 3.1 min.), attributed to the longer time spent by males in attentive behavior when plastic balls were placed in the feeders. There was no effect on composite behavioral score. Both males (18.37%) and females (14.29%) were classified as calm while feeding in feeders with unfamiliar objects. By adding plastic balls to the feeder, it was possible to increase the feeding time of foals fed concentrate feed.

Keywords: behavior; equine; feeder; feeding time; horse; management.

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Introduction

Concentrate feed is present in most equine diets, especially for animals with elevated nutritional requirements or in the growing phase (National Research Council [NRC], 2007). However, diets containing a higher proportion of concentrate than roughage may lead to the development of gastrointestinal conditions, such as colic (Clarke, Roberts, & Argenzio, 1990; Malamed, Berger, Bain, Kass, & Spier, 2010), as well as behavioral disorders (Hothersall & Nicol, 2009; Ribeiro et al., 2019). Short feeding periods combined with long intervals between meals may promote abnormal or stereotypic behaviors in horses (Ninomiya, Sato, & Sugawara, 2007; Sarrafchi & Blokhuis, 2013; Roberts, Hemmings, McBride, & Parker, 2017; Ribeiro et al., 2019).

Several studies investigated the use of slow feeders to increase the time of roughage consumption (Ellis et al., 2015; Rochais, Henry, & Hausberger, 2018; Ribeiro et al., 2019; Correa et al., 2020). However, no attention seems to have been devoted to the time horses spend eating concentrate. Slow ingestion of concentrate is key to its efficient use (NRC, 2007).

As an alternative to slow feeders, large stones or iron spheres (> 8 cm diameter) placed inside feeders have been used to reduce feeding time. However, little is known about the efficiency of such objects in reducing feeding time or if they may negatively impact horse health and behavior, causing, for instance, muzzle cartilage damage or increased reactivity (McDonnell & Poulin, 2002). A safer, more economical strategy to reduce feeding time without posing a risk to horse health would be to use plastic balls.

Anxiety may be an important factor influencing the feeding time of horses. Reactivity assessment can help elucidate the acceptance of novel objects by horses and the viability of exposing them to unfamiliar objects during feeding (Calviello et al., 2015; Calviello et al., 2016).

In view of the foregoing, this study aimed to evaluate the feeding time and reactivity of foals exposed to novel objects (plastic balls) in feeders.

Material and methods

This study was conducted in accordance with Animal Research: Reporting of *in vivo* Experiments (Arrive) guidelines and was approved by the Animal Ethics Committee (Ceua) of the School of Animal Science and Food Engineering, University of São Paulo, Brazil (protocol no. 2673240516). Experimental procedures involved behavioral observations and non-invasive interactions with horses.

Experimental design, animals, diets, and data collection

A repeated measures design was used to analyze the effect of novel objects on feeding time and foal reactivity. The field experiment lasted 4 days. Eleven mixed-breed foals (males = 6; 12 ± 2 months old; 316 ± 42 kg body weight; females = 5; 10 ± 2 months old; 290 ± 35 kg body weight) were used. Foals were previously weighed using a portable balance (KM3-N, Coimma, Dracena, São Paulo, Brazil). All animals were clinically healthy and considered eligible to participate in this study.

The foals were housed in a paddock (60 m^2), where Coast Cross (*Cynodon dactylon*) was the predominant forage species. Foals were taken daily (7:00 a.m.) to a stable to consume concentrate feed. The animals remained in the stall unit only during feeding. The feeding stall was composed of 20 individual units measuring 2 m^2 (1 × 2 m) (Figure 1).

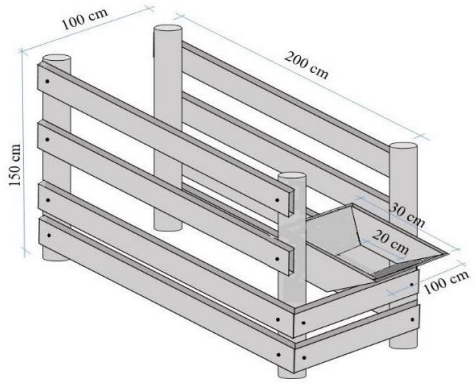

Figure 1. Schematic model of the feeding stall unit.

Each individual stall had a gate that was closed, preventing the foal from leaving and another animal from entering the area. Box stalls were arranged side by side so that horses could see their neighbors. Each stall was equipped with a feeder (for concentrate feed) measuring approximately 0.03 m^2 (30 × 100 cm). The foals were already accustomed to the feeding stall.

Concentrate feed was composed mainly of corn meal, soybean meal, wheat bran, vitamin–mineral premix, antifungal agents, and antioxidants. It was formulated to provide 30% of the nutritional requirements of growing horses (NRC, 2007), containing 2.8 Mcal kg^{-1} digestible energy and 12% crude protein. The amount of concentrate provided to each animal was calculated based on the animal's age and body weight, according to NRC (2007). The mean daily ration of concentrate was 1773 ± 261 g (males = 2000 g and females = 1500 g).

All foals were subjected to two treatments in different periods. The control treatment consisted of feeders without objects. For the test treatment, seven blue plastic balls measuring 8 cm in diameter and weighing 3 g each were introduced into the feeders. Following accommodation of foals in the feeding stall, concentrate was offered and the feeding time was recorded from the moment the animals started eating. Feeding time was defined as the time spent consuming concentrate feed. A stopwatch (T-TIM-0010.00, Incoterm, Porto Alegre, Brazil) was used for measuring feeding time. The animals were observed for three days, and the average feeding time was calculated. Observations were made during the feeding period by an observer positioned about 3 m away from the feeder.

Behavioral observation

Behavioral observations were performed by the continuous visual method, according to a method adapted from Calviello et al. (2015). First, foals were locked in the feeding stall. The behavioral assessment started when animals looked at the feeder. Four behavioral variables (eye position, ear position, vocalization, and snorting) were scored using an ethogram (Table 1). The occurrence frequency was calculated as percentage. Scores were summed to obtain a composite value representing the level of reactivity of each animal.

Table 1. Ethogram of facial expressions (eye and ear position) and behaviors observed during horse feeding.

Item	Score	Description
Eye position		
Relaxed	1	Predominance (within feeding time) of eyes showing relaxed eyelids (without contraction of the inner eyebrow raiser).
Attentive or concerned	2	Predominance (within feeding time) of attentive and focused expressions, with eyes watching what happens around.
Wide or surprised	3	Predominance (within feeding time) of eye expressions reflecting fear or anger.
Ear position		
Relaxed	1	Predominance (within feeding time) of ears held loosely upward, with openings facing outward.
Attentive	2	Predominance (within feeding time) of ears held stiff, with openings pointed directly forward.
Rapidly swiveling	3	Predominance (within feeding time) of ears in constant movement (shifting position).
Vocalization		
Absent	1	Animal remains silent for 1 min.
Occasional	2	Eventual calls or answers, through neighs or whinnies, with a frequency of up to one occurrence (within feeding time).
Frequent	3	Constants calls or answers, through neighs or whinnies, with a frequency of two or more occurrences (within feeding time).
Snorting		
No	1	No occurrences within feeding time.
Yes	2	At least one occurrence within feeding time.

Reactivity was classified by using a composite score of variables, based on the concepts of the Likert scale (1932). Score 1 was assigned to the less reactive behavior, and higher scores were assigned to more reactive responses. Each foal was scored on each analyzed parameter, and scores were added to give the total score of the animal. The highest possible total score (representing the highest level of reactivity) was found to be 11, estimated by adding the highest score possible for each variable. The reactivity of horses to the test was estimated as the ratio between the total individual score and the highest possible total score, as shown below.

$$Composite\ score\ (\%) = \frac{Total\ score\ of\ the\ individual}{11\ (highest\ possible\ score\ for\ the\ test)} \times 100$$

Calviello et al. (2016) ranked foals according to composite scores. Five reactivity categories were determined, namely calm (0-20%), slightly reactive (21%-40%), reactive (41%-60%), very reactive (61%-80%), and aggressive (81%-100%).

Statistical analysis

Data on feeding time were subjected to analysis of variance and regression analysis ($p < 0.05$). Correlations between feeding time with (y) and without (x) novel objects in feeders were investigated using the PROC REG procedure (with object = without object). A line of equality was used to test correlations, where $y = x$. Analyses were performed using SAS software version 9 (SAS Institute Inc., Cary, United States).

The model used for behavior analysis was fitted by the generalized linear model proposed by Nelder and Wedderburn (1972), with the GLIMMIX procedure of SAS. The effect of animal was considered in a repeated measures design, as well as the fixed effect of treatment, sex, and their interactions. Means were compared by the t-test (PDIFF). Significance was set at $p < 0.05$, and all values are presented as the mean and standard error of the mean (SEM). Analyses were conducted using SAS software version 9 (SAS Institute Inc., Cary, United States).

Results and discussion

There was no effect of sex ($p > 0.05$) on composite score; both males (18.37%) and females (14.29%) were classified as calm while feeding in the presence of novel objects in the feeder (Table 2). Although composite scores did not differ significantly between sexes ($p > 0.05$), it was possible to observe a difference in the behavior of male and female foals. Males were more attentive (77.8%) and less relaxed (22.2%) than females (Table 2). The composite reactivity score indicated that foals were calm during feeding at the slow-feeding device. This finding, combined with the increase in feeding time, suggests that animals were comfortable during the experiments. Foals did not chew or play with plastic balls during or after feeding. It is possible that objects were considered solely as obstacles to feeding. Calviello et al. (2016) stated that a low composite reactivity score indicates that horses accepted well the challenges to which they were exposed.

Feeding time was similar between treatments, with a mean of 21.6 ± 4.5 min. In experiments without novel objects, the feeding time was 21.7 ± 4.3 min, and in experiments with novel objects, the experiment time was 21.4 ± 4.8 min. Nevertheless, a weak correlation (R^2 = 0.448) was observed between treatments, indicating that feeding times did not follow a clear trend. The slope of the regression line was different from 1 and less than 45°, indicating that feeding time was longer when feeders contained plastic balls (Figure 2A). Furthermore, feeding time differed when evaluating sexes separately (males = 23.7 ± 4.8 min.; females = 19.5 ± 3.1 min.) because of differences in the amount of feed offered to each sex (Figure 2). In analyzing models stratified for males (Figure 2B) and females (Figure 2C), it was confirmed that feeding was prolonged when foals were exposed to novel objects in feeders (males, mean increment of 0.17 min.; females, mean increment of 0.86 min.).

Table 2. Mean frequency of behavior occurrence, stratified by sex.

Item	Frequency (%)			p-value
	Females	Males	Mean	
Eye position				
Relaxed	53.3	22.2	36.4	0.07
Attentive or concerned	46.7	77.8	63.6	0.07
Wide or surprised	0.00	0.00	0.00	1.00
Ear position				
Relaxed	100.0	83.3	99.9	0.98
Attentive	0.00	16.7	0.02	0.98
Rapidly swiveling	0.00	0.00	0.00	1.00
Vocalization				
Absent	100	100	100	1.00
Occasional	0.00	0.00	0.00	1.00
Frequent	0.00	0.00	0.00	1.00
Snorting				
No	0.00	5.56	0.03	0.96
Yes	100	94.4	99.9	0.96

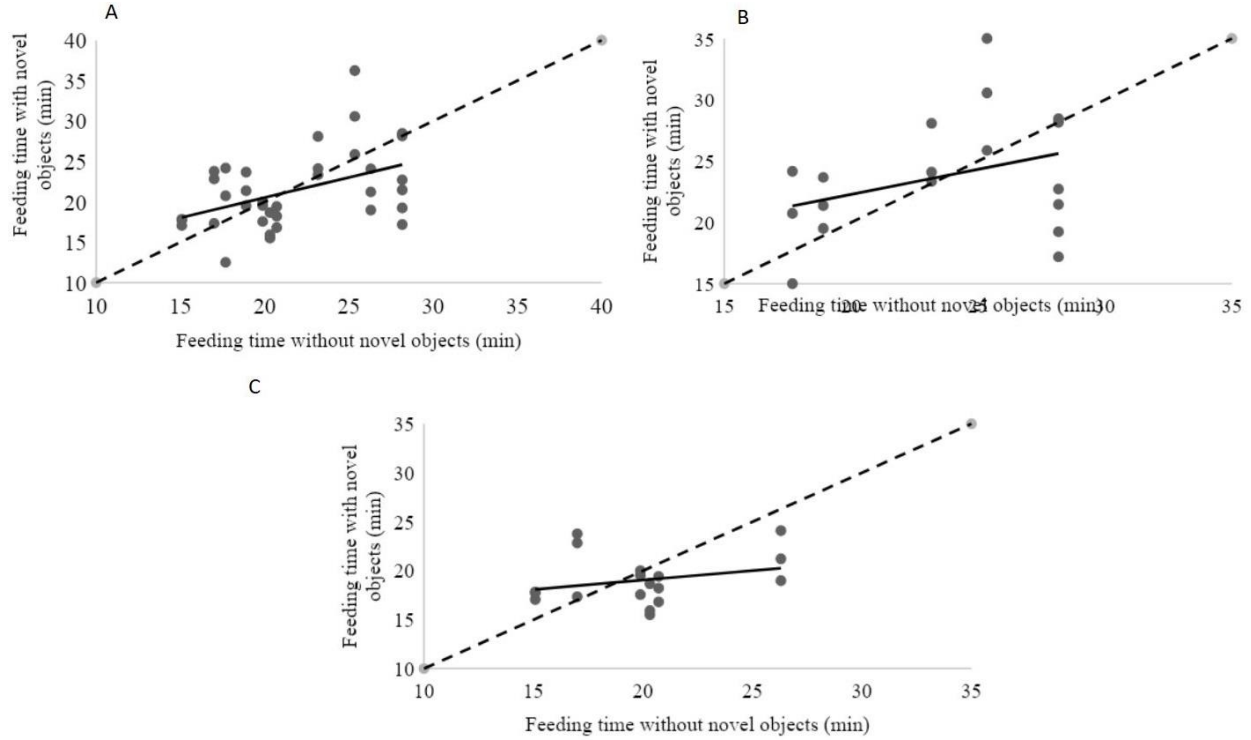

Figure 2. Relationship of horse feeding time in experiments with and without novel objects in feeders. The dashed line is the identity line, where $y = x$. (A) Regardless of sex, $y = 0.4772x + 11.077$, $R^2 = 0.201$, p < 0.0101, Root MSE = 4.342, CV = 20.27; (B) males, $y = 0.365x + 15.135$, $R^2 = 0.0774$, p < 0.2635, Root MSE = 5.281, CV = 22.26; and (C) females, $y = 0.1804x + 15.533$, $R^2 = 0.0654$, p < 0.3058, Root MSE = 2.485, CV = 13.01.

Addition of plastic balls to feeders resulted in an increase in feeding time among males, even though they were more attentive. Horses that remain stabled often experience anxiety and stress, showing similar

behavior to the males of the current study. The data for males had greater dispersion, suggesting a stronger influence of the individual characteristics of male foals on the results (Figure 2B).

We believe that if the horses used in the study had a higher reactivity rating, it would be easier to identify the effectiveness of plastic balls. Here, the effect was subtle on calm horses. A relaxed state favors the time spent by horses to bite and ingest feed. For better use of the diet, it is important that feed intake be done calmly, promoting correct mastication, salivation, and enzymatic action (NRC, 2007). Temporal distribution of feeding behavior is thus of primary importance in horses (Rochais et al., 2018). Short feeding time, reduced meal frequency, large intervals between meals, inadequate nutrient supply, long confinement time, and poor housing conditions are stress-causing agents in horses (Sarrafchi & Blokhuis, 2013; Ribeiro et al., 2019) and some of the main causes of undesirable behavior (Hothersall & Nicol, 2009; Ellis et al., 2015; Rochais et al., 2018). For instance, interaction effects between feeding time and digestive capacity are known to have a large influence on the development of crib-biting behavior. Under stressful conditions, horses tend to eat concentrate feed rapidly (Elia, Erb, & Houpt, 2010), probably driven by anxiety or fear of competition and hunger (Elia et al., 2010; Burla, Ostertag, Patt, Bachmann, & Hillmann, 2016). The literature on the feeding time of foals or adult horses fed concentrate feed is scarce, underscoring the importance of the current study.

Previous studies suggested providing smaller meals and offering concentrate feed in thinner layers, which stimulates animals to seek food, thereby increasing feeding time (Vervuert, Voigt, Hollands, Cuddeford, & Coenen, 2009; Gülden, Zurmussen, & Büscher, 2018; Rochais et al., 2018). The increase in feeding time with the use of plastic balls in feeders reinforces the importance of knowledge in this area, reiterating the benefits cited by the NRC (2007). These effects may also promote a decrease in idle time, contributing to welfare.

Rochais et al. (2018) reported that horse owners seek solutions to improve horse welfare through appropriate feeding strategies. Increasing feeding time without causing frustration or stress is paramount to horse welfare. Despite being simple, the use of plastic balls led to a slight increase in feeding time (Figure 2) and caused little frustration, as evidenced by behavior analysis (Table 2).

The results of the current study confirm the hypothesis that simple and light objects, such as plastic balls, can increase feeding time. Our results underscore the potential of novel objects as an alternative tool to increase feeding time in stabled animals fed concentrate feed. In a future study, we intend to repeat the experiment on known nervous horses and observe the effectiveness of the strategy, in addition to varying feeding places.

Conclusion

It was possible to increase the feeding time of foals fed concentrate feed in feeders containing novel objects (plastic balls), even for the most attentive animals.

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