

Paddock Behaviors and Dominance Relationships of Young Male Horses The First Hour in the Morning and Again in the Afternoon

¹Akin Yakan, ⁴Aytac Akcay, ⁵Serhan Durmaz, ²Taylan Aksu and ³Hasan Ozturk

¹Department of Animal Science,

²Department of Animal Nutrition, Faculty of Veterinary Medicine,

³Department of Biochemistry, Faculty of Medicine, University of Mustafa Kemal, Hatay, Turkey

⁴Department of Biostatistics, Faculty of Veterinary, University of Erciyes, Kayseri, Turkey

⁵Department of Fertility and Artificial Insemination, University of Ondokuz Mayıs,
Graduate School of Health Sciences, Samsun, Turkey

Abstract: The time budget, frequency of physiological necessities and factors related to dominance rank were studied in Cold Blooded Breed (CBB) and Warm Blooded Breed (WBB) male horses. The subjects were investigated during the 1st h in a paddock after confinement in the morning and again in the afternoon. Proportion of feeding was the largest among time budget activities and significantly different ($p < 0.05$) between observation periods. Proportions of locomotion, resting and playing were statistically different ($p < 0.05$; $p < 0.01$ and $p < 0.001$) between both breeds and both observation periods. No differences were found for living activities such feeding, drinking and elimination (urination and defecation) between the CBB and WBB horses. Dominance hierarchy was linear and positively correlated ($p < 0.01$) with weight but not serum testosterone levels and age. The results showed that feeding activity was very important at the 1st h in the paddock. Additionally, the weight of the colts had an effect on dominance rank.

Key words: Colts, paddock behaviors, dominance relationship, serum testosterone level, locomotion

INTRODUCTION

The paddock behavior observations of domesticated equids can provide important information to improve knowledge about their management. The horses are generally kept in individual boxes which limit contact between the horses (Rose-Meierhofer *et al.*, 2010). Stallions and colts are especially regarded as being aggressive towards one another (Christiansen *et al.*, 2002). The study by Mal *et al.* (1991) showed increasing locomotion behavior in the paddock after short-term confinement (48 h) of mares. There are also several other studies that show compensatory locomotor behavior in horses in response to exercise deprivation (Houpt *et al.*, 2001; Chaya *et al.*, 2006; Kurvers *et al.*, 2006; Chaplin and Gretgrix, 2010). For this reason, elapsed times in the paddock are very important for normal social behaviors and daily activities in the paddock and after overnight.

It is possible that the diversity of type and behavior within the domestic horse could pre-date domestication to some extent if the multiple domestication event hypothesis is accepted (Casey, 2002). This could in part account for variations in the morphology and behavior of Warm Blooded Breed (WBB) and Cold Blooded Breed

(CBB) horses. While WBB horses are fast and highly reactive, CBB horses are generally heavier built and have a less reactive temperament (Ozbeyaz and Akcapinar, 1999; Casey, 2002). Most ungulates such as red deer, antelope and horses, breed by establishing a hierarchical system (McDonnell and Murray, 1995). It was pointed out that male competition for access to a limited amount of food, water and females often results in high levels of male-male aggression. The reports about the relationship between the social behaviors and gonadal steroid hormones in animals are both limited and conflicting (Rose *et al.*, 1971; Chunwang *et al.*, 2004). Young horses are generally kept in individual boxes and as such the problems associated with accommodation of horses in individual boxes usually arise. Similarly, the differences between indicated behaviors that occur when horses are first leagued together and after they have been together in a paddock for a few hours is not known. For this reason, paddock behaviors and dominance relationships between horses are important when horses are turned out from individual boxes to the paddock.

The aim of this study was to investigate time budgets (focused on feeding, locomotion, resting and playing), physiological necessities (focused on drinking,

defecation, urination and rolling) and dominance rank and their relationship to serum testosterone levels, body weight and age in WBB/CBB horses in different daytime (morning and afternoon) time periods. All behaviors and dominance relationships were evaluated only for the 1st h after the horses were accessed to the paddock because determination of the first reaction between the horses was aimed at daily activities and dominance relationships.

MATERIALS AND METHODS

Animals and management: Data of the present study were collected from ten standard breed colts during paddock sessions. The colts which were born in same season consisted of seven WBB and three CBB (Table 1) horses. The colts were individually recognized by differences in body size, morphology, halter color and coat color. The daily and management program of the colts are shown in Table 2. The paddock area which isolated the study's colts from another horses was 0.15 ha (50×30 m) and separated by fencing (Fig. 1). All the colts used the same environmental area (boxes, paddock, etc.) after weaning. While the colts were provided with 3 kg day⁻¹ of concentrate feed (divided into three meals, shown in Table 2) which included 13.4% crude protein and 2600 kcal kg⁻¹ ME in stable, 10 kg day⁻¹ of dried meadow grass (divided into two meals, one given at the start of the morning and the other given during the afternoon observation periods) was given to each colt in the paddock. The colts had free access to water.

Data collection: The study was conducted between the middle of July and the end of August, 2009. All records for the study were collected using a digital camera (Sony Cyber Shot DSC-H7) in full HD. Before the study, a preliminary recording was made for 1 week in order to get the colts accustomed to the presence of the observer who kept a minimum 3 m distance from the colts and 3 m distance from the ground. Recordings were performed for 44 days, during the first 1 h in the morning paddock period (between 08:00 and 09:00) and during the 1st 1 h in the afternoon paddock period (between 14:00 and 15:00), giving a total of 39 h of morning observations and 37 h of afternoon observations. Some days (5 days for the morning period and 7 days for the afternoon period) were not recorded due to circumstances beyond the control. The WBB colts were evaluated a total of 273 times with 39 repeating observations in the morning; also a total of 259 times with 37 repeating observations in the afternoon. On the other hand, the CBB colts were evaluated a total of 117 times with 39 repeating observations in the morning; also a total of 111 times with 37 repeating observations in the afternoon.

Table 1: Data on individual characteristics of subjects

Label of colt name	Breed	Weight (kg)	Age (month)
Kr	Warm-blooded	435	16.5
Kd	Warm-blooded	453	15.5
Yd	Warm-blooded	410	16.5
Md	Warm-blooded	482	16.5
Sd	Warm-blooded	536	19.0
Ma	Warm-blooded	524	18.0
Ka	Warm-blooded	500	17.0
Kf	Cold-blooded	496	16.5
Mf	Cold-blooded	468	19.0
Yf	Cold-blooded	409	15.0

Table 2: Daily management program of the colts

Management program	Time
Morning concentrate feeding	06:00-07:00
Grooming time in stable	07:00-08:00
Morning paddock session	08:00-12:00
Midday concentrate feeding	12:00-13:00
Grooming time in stable	13:00-14:00
Afternoon paddock session	14:00-18:00
Evening concentrate feeding	18:00-19:00
Colts in stable	19:00-06:00

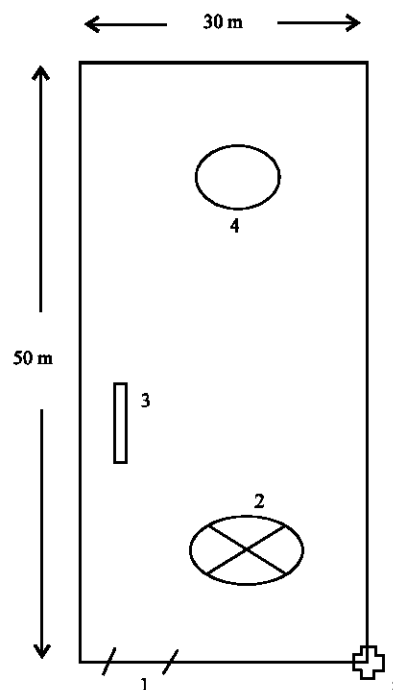


Fig. 1: Plan view of paddock system. 1: Door of paddock; 2: Hay rack; 3: Drinker; 4: Sandbox rollong; 5: Recording point

Data on social interactions were collected by focal sampling (Altmann, 1974). The following data were recorded: aggressiveness, time budgets which consist of feeding, locomotion, resting, playing and physiological necessities which consist of drinking, elimination and rolling (according to definitions by McDonnell and Poulin (2002), Heitor *et al.* (2006) and Heitor and Vicente (2010).

Table 3: Definition of behaviors recorded during observations

Behavior	Definition
Feeding	Individually feeding duration
Locomotion	That is performed while in motion at any gait
Resting	Standing inactive in a relaxed posture, head slightly lowered, eyes partly or nearly closed, often bearing weight on three legs
Playing	Play involves chasing, playful fighting, nipping, etc.
Rolling	An activity characterized by lying down and rolling onto back accompanied by rubbing movement against the ground
Aggressiveness	Through laid back ears, lowered head and neck, dominant body positioning, raising of hind leg or actual kick or bite

The definitions of the behaviors recorded during the observations are shown in Table 3. Aggressiveness was measured as the mean number and reflects behaviors from both the initiator and the receiver from each individual per the record.

Blood samples for testosterone analyses were collected twice a week during a 6 week time period (12 times in total) at early morning (07:00) via the jugular vein. Blood in plain tubes was allowed to clot at room temperature then kept at +4°C and serum was collected by centrifugation. Serum samples were stored at -20°C until assayed.

Data analysis: Student t-test was used to test for proportion of time budgets in each activity by the colts. The results were expressed as the mean±SEM (Standard Error of Mean). Physiological necessities and the calculated frequency of each activity in each observation period were analyzed with the median test.

Dominance relationships were assessed by the distribution of aggressiveness interactions between the colts excluding play fighting due to added play behaviors. The K_s matrix correlation test was used to measure asymmetry which was defined as a significant negative association between emission and receipt matrices (Hemelrijk, 1990). The linearity of dominance relationships was significant as assessed by the Kendall's coefficient of consistence K , based on the number of circular triads. Hence, the colts were ordered in a linear hierarchy by the I and SI Method (De Vries, 1998) which finds a ranking of individuals by first minimizing the number of inconsistencies. Individuals were then assigned an ordinal rank, increasing from the bottom to the top of the hierarchy. Spearman's rank correlation coefficient (r_s) was used to calculate correlations between dominance rank and serum testosterone levels, weight and age. Researchers computed aggressiveness as the mean frequency of agonistic interaction both initiated and received from each individual (total aggressiveness) and mean frequency of agonistic interactions were given to each subordinate (aggressiveness toward subordinates).

The level of serum testosterone was detected with the RIA kit (Diagnostic System Lab, Webster, TX, USA). The minimum detectable level of testosterone was 0.10 ng mL⁻¹; the mean intra- and inter-assay coefficients

of variations were 5.8 and 9.2%, respectively. All samples were performed in duplicate and within one assay. The data analysis was carried out using the SPSS 15 Statistical Package (SPSS, Chicago, IL, USA).

RESULTS AND DISCUSSION

Proportion of time the colts spent in feeding, locomotion, resting and playing were calculated and are presented in Table 4. While the feeding behavior for the WBB group (73.16±1.95% in both periods) and the CBB group (67.26±3.11% in both periods) occupied the largest percent, locomotion occupied the lowest percent (5.25±0.35% in both periods for the WBB colts and 6.83±0.67% in both periods for CBB colts) during the 1st h following paddock release. The percent of feeding, locomotion and playing was significantly different ($p<0.05$; $p<0.01$; $p<0.001$) between the morning and the afternoon observation periods for the WBB colts but was not different for all of the CBB colts. Additionally, percent of feeding, resting and locomotion were significantly different ($p<0.05$; $p<0.001$) between the WBB colts and the CBB colts for the morning observation period.

Frequencies of physiological necessity are shown in Table 5. No significant differences were found for obligate activities for living (drinking, defecation and urination) while rolling was statistically different ($p<0.01$) between the WBB and the CBB colts. Furthermore, elimination location was recorded.

A total of 1048 colt-colt aggressiveness behaviors were recorded for 10 colts during the observation periods. The compiled dominance matrix and linear dominant hierarchy is based on colt-colt aggressive encounters (Table 6). Aggressiveness was generally higher among the warm-blooded colts than the cold-blooded colts. Cold-blooded colts were near other cold-blooded colts in the dominance rank which had a range of 5, 7 and 8. The dominance rank of individuals and the correlations among dominance rank, serum testosterone levels, weight and age are shown in Fig. 2. While dominance rank was statistically ($p<0.01$) positively correlated with weight, it was not significantly correlated with serum testosterone levels and age. Additionally, weight was positively correlated with serum testosterone levels and age ($p<0.05$).

While earlier research studies (Autio and Heiskanen, 2005; Ransom and Cade, 2009; Ransom *et al.*, 2010) indicated that the largest amount of time in the daily time budget of horses is allocated to feeding, Heleski *et al.* (2002) and Heitor and Vicente (2010) reported that feeding and resting took approximately equal time. This condition may change due to age, duration of observation, exercise, paddock size and housing system (Heleski *et al.*, 2002; Autio and Heiskanen, 2005; Jorgensen and Boe, 2007; Ransom and Cade, 2009; Ransom *et al.*, 2010). In this study, feeding proportion was higher (63.96-78.71%) than in earlier studies (Heleski *et al.*, 2002; Autio and Heiskanen, 2005; Ransom and Cade, 2009; Ransom *et al.*, 2010; Heitor and Vicente, 2010) because recordings were performed for 1 h, immediately after the colts turned to the paddock. The horses spent more time in feeding activity in the morning than during the afternoon observation periods (78.71 vs. 65.19% for the WBB colts; 69.50 vs. 63.96% for the CBB colts). This situation may be due to the lack of dried meadow grass for approximately 11 h at night. After the colts were returned to the paddock, they preferred feeding rather than engaging in other paddock activities in the mornings ($p<0.05$). The colts could feed nearly 6 h before

the afternoon observations. So, they spent plenty of time engaging in social activities in afternoons. This comment could be confirmed with the increased locomotion and the decreased feeding activity during the afternoon observations. On the other hand, the reason for the reduction of the proportion of feeding may be due to the increased environmental temperature in the afternoon as compared to the morning, since higher environmental temperatures have been stated to limit feed consumption due to the restriction of heat production which is the source of body temperature (Ozbeyaz and Akcapinar, 1999).

Resting took the second largest time budget in the paddock in accordance with the statements of Ransom and Cade (2009). Different researchers McDonnell and Murray (1995), Heleski *et al.* (2002), Autio and Heiskanen (2005), Heitor and Vicente (2010) and Ransom *et al.* (2010) reported that the time spent for resting was found to be between 27.1 and 46.6% of the daily time budget. These proportions were higher than what was found in the present study results because feeding occupied the largest amount of time budgets in our study. According to the results, the values of resting for the CBB colts and the afternoon observation periods were higher than the values of resting for the WBB colts and the morning observation periods. While the reason for the difference between the breeds could be related to the calm temperament and less reactive character of the

Individuals	Serum testosterone levels (n = 12)	Weight (kg)	Age (month)
Ascending			
Sd	0.82±0.25 ng mL ⁻¹	536	19
Ma	0.42±0.10 ng mL ⁻¹	524	18
Md	0.21±0.07 ng mL ⁻¹	482	16.5
Ka	0.51±0.15 ng mL ⁻¹	500	17
Dominance rank			
Kf	0.33±0.06 ng mL ⁻¹	496	16.5
Kd	0.26±0.11 ng mL ⁻¹	453	15.5
Mf	0.40±0.04 ng mL ⁻¹	468	19
Yf	0.39±0.06 ng mL ⁻¹	409	15
Descending			
Yd	0.20±0.04 ng mL ⁻¹	410	16.5
Kr	0.23±0.08 ng mL ⁻¹	435	16.5
Correlations			
Dominance rank	0.600	0.903**	0.514
Serum testosterone levels	-	0.685*	0.621
Weight	-	-	0.728*

* $p<0.05$, ** $p<0.01$

Fig. 2: Dominance rank and correlations among factors

Table 4: Time budgets of observed colts: mean percentage in the different activities (mean±SE)

Items (%)	Feeding	Resting	Locomotion	Playing
WBB	*	NS	*	**
Morning (n = 273)	78.71±2.29	9.04±1.40	4.48±0.40	7.75±1.04
Afternoon (n = 259)	65.19±3.30	15.23±1.75	6.35±0.63	13.21±1.69
CBB	NS	NS	NS	NS
Morning (n = 117)	69.50±4.00	17.57±2.96	6.28±0.83	6.62±1.30
Afternoon (n = 117)	63.96±4.98	21.77±3.60	7.64±1.11	6.61±1.35
WBB×CBB				
Morning	*	***	*	NS
Afternoon	NS	*	NS	***
Both periods	*	*	NS	**

NS: No Significance; * $p<0.05$; ** $p<0.01$; *** $p<0.001$; Feeding + Resting + Locomotion + Playing = 100

Table 5: Frequencies of physiological necessity in paddock

Frequencies	Drinking		Defecation		Urination		Rolling	
	WBB	CBB	WBB	CBB	WBB	CBB	WBB	CBB
0	33 (12.7%)	11 (9.9%)	164 (63.3%)	59 (53.2%)	191 (73.7%)	76 (68.5%)	211 (81.5%)	103 (92.8%)
1	110 (42.5%)	54 (48.6%)	74 (28.6%)	40 (36.0%)	63 (24.3%)	30 (27.0%)	37 (14.3%)	7 (6.3%)
2	76 (29.3%)	36 (32.4%)	19 (7.3%)	9 (8.1%)	5 (1.9%)	5 (4.5%)	10 (3.9%)	1 (0.9%)
3	25 (9.7%)	-	-	3 (2.7%)	-	-	1 (0.4%)	-
4	11 (4.2%)	9 (8.1%)	-	-	-	-	-	-
5	4 (1.5%)	1 (0.9%)	-	-	-	-	-	-
Median-Mod	1-1	1-1	0-0	0-0	0-0	0-0	0-0	0-0
Percentiles (25, 75%)	1, 2	1, 2	0, 1	0, 1	0, 1	0, 1	0, 0	0, 0
Significance	$p>0.05$		$p>0.05$		$p>0.05$		$p<0.01$	

Table 6: Total number of aggressiveness that caused withdrawal or avoidance reactions

Initiator											
Receiver	Kr	Yd	Yf	Mf	Kd	Kf	Ka	Md	Ma	Sd	Total
Kr	-	10	14	12	13	11	18	23	37	48	186
Yd	3	-	16	12	25	13	15	19	37	70	210
Yf	0	3	-	10	11	9	12	10	16	43	114
Mf	0	1	2	-	10	8	10	9	17	40	97
Kd	0	3	2	3	-	13	12	16	29	62	140
Kf	0	0	0	0	1	-	11	11	21	48	92
Ka	1	3	1	2	8	3	-	12	38	46	76
Md	0	0	1	2	1	1	2	-	16	28	51
Ma	0	1	3	6	3	13	3	5	-	46	80
Sd	0	0	0	0	0	0	0	1	1	-	2
Total	4	21	30	47	72	71	83	106	212	431	1048

Individuals are disposed in ascending order of dominance rank from left to right in column labels and top to bottom in row labels

CBB colts (Casey, 2002), the reason for the difference between the observation periods could be associated with the decreased feed consumption due to the increased environmental temperature and also the increase in the resting proportion.

Locomotion occupied a relatively small amount (4.48-7.64%) of the time budgets. The results are consistent with the results of the studies reported by Heleski *et al.* (2002), Heitor and Vicente (2010) and Ransom *et al.* (2010). Researchers found that duration of locomotion for the CBB colts was longer (5.25 vs. 6.83%) than it was for the WBB colts. This result is in contrast to the hypotheses that stipulated that CBB horses are known to have both a calm temperament and to be less reactive than WBB horses (Casey, 2002).

In the study, the results showed that the time budget of playing did not occupy an important place among paddock activities (6.61-13.21%). The playing activity took more time in the afternoon observations than in the morning observations in the WBB colts. This situation may be linked with the feeding activity. While the proportion of feeding was reduced, the proportion of playing was increased during the afternoon observation periods (Table 4).

Frequencies of physiological necessity were calculated as drinking, defecation, urination and rolling between the WBB and the CBB colts. It is important to note that maintenance behaviors (drinking, defecation and urination) were not different between the WBB and the CBB colts while rolling, admitted grooming and comfort behavior (Ransom and Cade, 2009) were higher in the WBB colts than in the CBB colts. This finding may possibly be due to breed characteristics. For elimination frequencies, the results were at a normal level because elimination behavior had been reported as occurring once every 3-4.5 h for urination and once every 2-5 h for defecation (Boyd, 1988; Benhajali *et al.*, 2008). On the other hand, it was observed that urination could be performed at the feeding place but not defecation.

Agonism among horses is exhibited by a wide range of behaviors (Ransom and Cade, 2009) and aggressiveness was noted as a determination of agonism in this study. Most aggressive interactions performed among the colts were displayed as threats, not involving physical contact. One of the aims of this study was to examine both the determinate of dominance rank and the correlation between dominance rank and other factors (serum testosterone level, weight and age). The dominance rank was linear among the colts which was also reported for other bachelor groups (Heitor *et al.*, 2006; Vervaecke *et al.*, 2007; Zharkikh and Anderson, 2009; Heitor and Vicente, 2010). The WBB colts were generally higher than the CBB colts in terms of dominance rank. Rank was 1, 2, 3, 4, 6, 9 and 10 versus 5, 7 and 8 (Fig. 2). This situation might possibly be due to each breed's characteristics and weights. The higher-ranking dominants (except Md) were heavier than all the cold-blooded colts.

Dominance rank may depend on a horse's age (Rutberg and Greenberg, 1990; Sigurjonsdottir *et al.*, 2003; Rho *et al.*, 2004; Heitor *et al.*, 2006; Powell, 2008) but in the present study, the correlation between dominance rank and age was not detected as being similar to Houpt *et al.* (1978). Some researchers hold the opinion that if the age range among horses is wide, the correlation can be significant between dominance rank and age when the age range is close, the correlation can't be. In this study, the reason for the non-correlation between dominance rank and age could be linked to the close age range among the colts.

There has been much discussion about the influence of testosterone in aggressive behavior and for many male mammals testosterone seems to increase aggressive behavior (Van, 2001). While dominance rank was correlated with serum testosterone levels in Rhesus Monkeys (Rose *et al.*, 1971) and was correlated in Pere David's Deer Stags (Chunwang *et al.*, 2004) in this study dominance rank was not correlated with serum testosterone levels as was found in other studies on horses (Line *et al.*, 1985; Van, 2001). It is believed that the influence of testosterone on dominance rank varies greatly among species.

While dominance rank was not correlated with serum testosterone levels, age was only significantly correlated with weight. However, the lightest colts did not occupy the lowest position in the hierarchy. These findings are in accordance with the reports of some researchers (Houpt *et al.*, 1978; Van, 2001).

Both serum testosterone levels/weight and weight/age were significantly positively correlated. Generally, these correlations are consistent with other findings (Ozbeyaz and Akcapinar 1999; Brown-Douglas *et al.*, 2004).

CONCLUSION

The results of this study indicated that the most important activity of colts is feeding at the 1st h in the paddock. The colts spend a lot of time engaging in social behavior after they have eaten. These findings support and are consistent with their metabolic needs. The proportion of the time budget can be also changed between both breeds of colts and during different daylight hours. It was observed that maintenance behaviors such as feeding, drinking and elimination were not different between the breeds while rolling was different between the breeds. Dominance rank has been related to the weight of the colts. It was determined that the CBB colts were of modest weight and demonstrated a middle-low place in the dominance rank. These implications suggest that paddock and herd management rules should be established according to these findings. It is advised that the horses should be fed with hay at night. The colts would be separated according to live weight in the paddock due to the positive correlation between weight and dominance rank. Therefore, these results should not be generalized to include all daylight hours because these findings were collected from the 1st h of the morning and during the first evening hour in the paddock. Further study should also require long-term observations.

REFERENCES

- Altmann, J., 1974. Observational study of behaviors: Sampling methods. *Behaviour*, 49: 227-267.
- Autio, E. and M.L. Heiskanen, 2005. Foal behaviour in a loose housing/paddock environment during winter. *Applied Anim. Behav. Sci.*, 91: 277-288.
- Benhajali, H., M. Richard-Yris, M. Leroux, M. Ezzaoui, F. Charfi and M. Hausberger, 2008. A note on the time budget and social behavior of densely housed horses: A case study in Arab breeding mares. *Applied Anim. Behav. Sci.*, 112: 196-200.
- Boyd, L.E., 1988. Time budget of adult Przewalski horses: Effect of sex, reproductive status and enclosure. *Applied Anim. Behav. Sci.*, 21: 19-39.
- Brown-Douglas, C.G., E.C. Firth, T.J. Parkinson and P.F. Fennessy, 2004. Onset of puberty in thoroughbred horses born in spring and autumn. *Equine Vet. J.*, 36: 499-504.
- Casey, R.A., 2002. The Welfare of Horse. In: *Horse Behaviour: Evolution, Domestication and Feralisation*, Waran, N. (Ed.). Kluwer Academic Publisher, Boston, MA, USA., pp: 5-6.
- Chaplin, J.S. and L. Gretgrix, 2010. Effect of housing conditions on activity and lying behavior of horses. *Animal*, 4: 792-795.
- Chaya, L., E. Cowan and B. McGuire, 2006. A note on the relationship between time spent in turnout and behavior turnout in horses (*Equus caballus*). *Applied Anim. Behav. Sci.*, 98: 155-160.
- Christensen, J.W., J. Ladewig, E. Sondergaard and J. Malmkvist, 2002. Effects of individual versus group stabling on social behaviour in domestic stallions. *Applied Anim. Behav. Sci.*, 75: 233-248.
- Chunwang, L., J. Zhigang, Z. Yan and Y. Caie, 2004. Relationship between serum testosterone, dominance and mating success in Pere David's Deer stags. *Ethology*, 110: 681-691.
- De Vries, H., 1998. Finding a dominance order most consistent with a linear hierarchy: A new procedure and review. *Anim. Behav.*, 55: 827-843.
- Heitor, F. and L. Vicente, 2010. Dominance relationships and pattern of aggression in a bachelor group of Sorraia horses (*Equus caballus*). *J. Ethology*, 28: 35-44.
- Heitor, F., M.D.M. Oom and L. Vicente, 2006. Social relationships in a herd of Sorraia horses Part I. Correlations of social dominance and contexts of aggression. *Behav. Processes*, 73: 170-177.
- Heleski, C.R., A.C. Shelle, B.D. Nielsen and A.J. Zanella, 2002. Influence of housing on weanling horse behavior and subsequent welfare. *Applied Anim. Behav. Sci.*, 78: 291-302.
- Hemelrijk, C.K., 1990. Models of and tests for reciprocity, unidirectionality and other social interaction pattern at a group level. *Anim. Behav.*, 39: 1013-1029.
- Houpt, K., T.R. Houpt, J.L. Johnson, H.N. Erb and S.C. Yean, 2001. The effect of exercise deprivation on the behavior and physiology of straight stall confined pregnant mares. *Anim. Welfare*, 10: 257-267.
- Houpt, K.A., K. Law and V. Martinisi, 1978. Dominance hierarchies in domestic horses. *Applied Anim. Behav. Sci.*, 4: 273-283.
- Jorgensen, G.H.M. and K.E. Boe, 2007. A note on the effect of daily exercise and paddock size on the behaviour of domestic horses (*Equus caballus*). *Applied Anim. Behav. Sci.*, 107: 166-173.
- Kurvers, C.M., P.R. Van Weeren, C.W. Rogers and M.C. Van Dierendonck, 2006. Quantification of spontaneous locomotion activity in foals kept in pastures under various management conditions. *Am. J. Vet. Res.*, 67: 1212-1217.
- Line, S.W., B.L. Hart and L. Sanders, 1985. Effect of prepubertal versus postpubertal castration on sexual and aggressive behaviour in male horses. *J. Am. Vet. Med. Assoc.*, 186: 249-251.

- Mal, M.E., T.H. Friend, D.C. Lay, S.G. Vogelsang and O.C. Jenkins, 1991. Behavioural responses of mares to short-term confinement and social isolation. *Applied Anim. Behav. Sci.*, 31: 13-24.
- McDonnell, S.M. and A. Poulin, 2002. Equid play ethogram. *Applied Anim. Behav. Sci.*, 78: 263-290.
- McDonnell, S.M. and S.C. Murray, 1995. Bachelor and harem stallion behavior and endocrinology. *Biol. Reprod.*, 1: 577-590.
- Ozbeyaz, C. and H. Akcapinar, 1999. Hayvan Yetistiriciligi Temel Bilgileri. Kariyer Matbaacilik Ltd. Sti, Ankara, ISBN: 975-96978-0-7, (In Turkish).
- Powell, D.M., 2008. Female-female competition or male mate choice? Pattern of courtship and breeding behavior among feral horses (*Equus caballus*) on Assateague Island. *J. Ethology*, 26: 137-144.
- Ransom, J.I. and B.S. Cade, 2009. Quantifying equid behavior- A research ethogram for free-roaming feral horses. US Geological Survey, <http://digitalcommons.unl.edu/usgspubs/26>.
- Ransom, J.I., B.S. Cade and N.T. Hobbs, 2010. Influences of immunocontraception on time budgets, social behavior, and body condition in feral horses. *Applied Anim. Behav. Sci.*, 124: 51-60.
- Rho, J.R., R.B. Srygley and J.C. Choe, 2004. Behavioral ecology of the Jeju pony (*Equus caballus*): Effects of maternal age, maternal dominance hierarchy and foal age on mare aggression. *Ecol. Res.*, 19: 55-63.
- Rose, R.M., J.W. Holaday and I.S. Bernstein, 1971. Plasma testosterone, dominance rank and aggressive behaviour in male rhesus monkeys. *Nature*, 231: 366-368.
- Rose-Meierhofer, S.R., S. Klaer, C. Ammon, R. Brunsch and G. Hoffmann, 2010. Activity behavior of horses housed in different open barn systems. *J. Equine Vet. Sci.*, 30: 624-634.
- Rutberg, A.T. and S.A. Greenberg, 1990. Dominance, aggression frequencies and modes of aggressive competition in feral pony mares. *Anim. Behav.*, 40: 322-331.
- Sigurjonsdottir, H., M.C. Van Dierendonck, S. Snorrason and A.G. Thorhallsdottir, 2003. Social relationships in a group of horses without a mature stallion. *Behaviour*, 140: 783-804.
- Van, D.J., 2001. Factors affecting dominance and aggressive interactions among castrated male domestic horses (*Equus caballus*). Thesis at Bachelor of Science, Department of Biology, Hartwick College, NY.
- Vervaecke, H., J.M.G. Stevens, H. Vandemoortele, H. Sigurjonsdottir and H. De Vries, 2007. Aggression and dominance in matched groups of subadult Icelandic horses (*Equus caballus*). *J. Ethology*, 25: 239-248.
- Zharkikh, T.L. and L. Andersen, 2009. Behaviour of bachelor males of the Przewalski horse (*Equus ferus przewalskii*) at the reserve Askania Nowa. *Zool. Garten*, 78: 282-299.