J Ethol (2010) 28:133–140
DOI 10.1007/s10164-009-0165-9

ARTICLE

Affiliative relationships among Sorraia mares: influence of age, dominance, kinship and reproductive state

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Received: 7 December 2007 / Accepted: 8 April 2009 / Published online: 16 May 2009

Abstract Affiliative relationships among mares were examined in a managed group of Sorraia horses, *Equus caballus*, over a 3-year period. We assessed the influence of age, dominance, kinship and reproductive state on the strength of affiliative relationships and diversity of partners. The herd comprised 9–11 mares that had known each other since birth, their foals and a stallion that remained in the group exclusively during the breeding season. In contrast to a previous study, kinship did not significantly affect bonds. Mares tended to spend more time in proximity to those in the same reproductive state. Affiliative relationships among mares were relatively stable but their strength decreased after foaling, possibly as a function of foal protection and bonding between dam and foal. There was no consistent evidence that mares disengaged from affiliative relationships with increasing age. As expected, dominant mares and barren mares contributed the most to affiliative relationships. Dominance rank increased with age, but dominance relationships were stable and did not change after foaling. Overall, reproductive state was the factor that had the most consistent influence on affiliative relationships among Sorraia mares.

Keywords Sorraia horse · Affiliative relationship · Dominance · Kinship · Reproductive state

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Introduction

The basic reproductive unit in feral horse populations is the band, a stable group composed of several mares, their offspring and one or more stallions that defend the mares from other males year round, as is typical of female defence polygyny (Tyler 1972; Salter and Hudson 1982; Kaseda et al. 1995; Linklater et al. 1999, Linklater 2000). Mares develop long lasting affiliative relationships which are reflected in spatial proximity and participation in affiliative interactions, such as mutual grooming (Tyler 1972; Wells and Von Goldschmidt-Rothschild 1979; Arnold and Grassia 1982; Kimura 1998). Bonds promote coordination of behaviour and band stability, which provides reproductive advantages to mares (Berger 1986; Kaseda et al. 1995; Linklater et al. 1999).

Factors affecting affiliative relationships between pairs of horses have been reported in several studies (Tyler 1972; Clutton-Brock et al. 1976; Wells and von Goldschmidt-Rothschild 1979; Kimura 1998; Sigurjónsdóttir et al. 2003). Nevertheless, factors affecting the diversity of partners and the relative contribution of each member of the pair to the relationship have rarely been examined. Knowledge about which individual and social factors are most important for the development of stable affiliative relationships in managed horse herds may help the implementation of more adequate management and husbandry practices. Such knowledge is particularly valuable for the conservation of the Sorraia horse, *Equus caballus*, a Portuguese autochthonous breed that presents high inbreeding levels (Luís 2006) and is considered to be at critical-maintained risk status by FAO (Scherf 2000).

In a previous study, where we tested the influence of age, dominance rank, kinship and aggressiveness on affiliative relationships among Sorraia mares, we found that bonds were based mainly on kinship coefficient (Heitor et al. 2006a). The finding was surprising, given the low variation in kinship coefficient among mare dyads, which could be suggestive of fine kin discrimination among group members. The influence of kinship on bonds among horses has been widely reported but usually refers to close relatives via the mother (e.g. mother–daughter, sisters). In natal bands, females bond most strongly with their mother and siblings (e.g. Tyler 1972; Wells and Von Goldschmidt-Rothschild 1979; Monard et al. 1996). These bonds are usually broken at the time of natal dispersal, but long-term bonds may develop among adult matrilineal relatives if they ever meet again (Tyler 1972; Waring 1983; Monard and Duncan 1996). To our knowledge, only Sigurjónsdóttir et al. (2003) had previously tested and found a relationship between kinship coefficient and bonds among horses.

Older mares could be expected to be more attractive social partners because they have greater experience and often longer residency in the herd, which could allow them to explore resources more efficiently and respond properly when they interact with group members and when they are confronted with sources of danger. However, a decline in sociability with aging has been observed in humans and nonhuman primates (Pavelka 1991; Veenema et al. 1997). If a similar decline occurs in horses, older mares would spend less time in proximity to others and initiate affiliative interactions less frequently. In addition, older mares may be expected to display lower diversity of partners than younger females, because preferences develop with time and familiarity (Sigurjónsdóttir et al. 2003).

Foaling may cause changes in previous bonds, as new mothers show active social disengagement and increased social isolation while they are raising a foal (Estep et al. 1993; Van Dierendonck et al. 2004). Moreover, new mothers sometimes rise temporarily in dominance rank (Klimov 1988; Van Dierendonck et al. 1995). Horse groups develop linear dominance hierarchies which are relatively stable and frequently based on age (e.g. Clutton-Brock et al. 1976; Wells and Von Goldschmidt-Rothschild 1979; Van Dierendonck et al. 1995; Sigurjónsdóttir et al. 2003; Heitor et al. 2006b). An individual's dominance status may constrain its role in bond formation and maintenance, because dominants can choose whom to bond with but subordinates cannot (Sigurjónsdóttir et al. 2003). Therefore, dominants or barren mares within each pair of horses may be expected to contribute more to an affiliative relationship than subordinates or mares with foals.

In the present study we assess the influence of age, dominance, kinship coefficient and reproductive state on the strength of affiliative relationships and diversity of partners among Sorraia mares. We tested the following hypotheses: (1) affiliative relationships are stronger (i) among mares with higher kinship and (ii) among mares in the same reproductive state; (2) strength of affiliative relationships and (3) diversity of partners decrease with (i) age and (ii) foaling; (4) but older mares receive higher frequencies of affiliative interactions; (5) contribution to affiliative relationships is highest by (i) dominant mares and (ii) barren mares; (6) dominance rank increases with (i) age and (ii) foaling.

Materials and methods

Subjects and study site

From 2003 to 2005, a horse herd kept at Alter studfarm (39°11′N, 7°39′W), Portugal, was observed as part of a research project on social relationships among Sorraia horses.

The subjects were 11 adult mares 4–22 years old that had known each other since birth. During the study period, there were a few changes in herd composition. In 2003, the youngest mare was removed from the group at the beginning of the study and was returned to it 8 months later. The oldest mare, which had been removed more than a year before this study, was returned to the group in 2003. Another mare died a few weeks after a miscarriage in 2005. Foaling usually occurred between February and May. Nineteen foals were born, of which one was a stillborn and five died within a few hours or days after birth. Around 9 months of age, foals are weaned and removed from the group, but some females rejoin the herd at 3 years of age to be bred. Each year, a stallion was introduced and kept in the mare group for pasture breeding between February and June: one stallion bred the mares from 2003 to 2004 and another in 2005.

The herd was kept on two 5.5- and 17.2-ha pastures enclosed by walls and 1.5-m high wire fences. Horses fed mainly on grasses and had ad libitum access to water from temporary water lines, watering-ponds and canals connected to reservoirs. During summer, supplemental feed (hay) was spread at specific sites on the ground and water was provided in a trough placed in the smaller pasture by the caretakers. The herd was taken to a paddock at least once every year for pregnancy detection, foal removal, branding, tail and mane shearing, collection of blood samples for paternity analyses or veterinary care.

Data collection

Observations were conducted on foot between 0630 and 1830 hours solar time, from a 3–10 m distance to the herd. In 2003, 25-min sample periods were performed on one mare at a time in random order and each mare was sampled at least once per week. During each period, we collected data on affiliative and agonistic-related interactions by focal sampling and data on spatial relationships by instantaneous sampling (Altmann 1974). For every observed social interaction, we recorded the type of interaction, identities of the initiator and receiver(s), reaction of the receiver(s) and context. Affiliative interactions included approaches across one body-length distance, following, mutual grooming, friendly contacts (body contacts made with ears forward or laterally positioned) and pairing (standing in antiparallel position, less than 0.5 m apart). To assess contribution to proximity, we also recorded leaves across one body-length distance. Agonistic-related interactions consisted of displacements, mild threats, bite threats, bites, kick threats, kicks, chases, attacks and herding (see Heitor et al. 2006b, for a description). Instantaneous samples were taken at 5-min intervals to record the identity of the focal mare's nearest neighbour and of her associates. The nearest neighbour was the horse closest to the focal mare. When two or more horses were at the same distance from the focal mare, the nearest neighbour was the one closest to her head. We registered one body-length and five body-lengths associates (i.e. horses within one body-length and horses between one and five body-lengths of the focal mare, respectively).

In 2004 and 2005, we collected only ad libitum data on agonistic-related interactions among mares to determine dominance relationships. Throughout the whole study period, maps showing relative positions of the horses were made at 1.5-h intervals. Overall, we performed 298 h of focal sampling (median 29.6 h per mare) over 459 h of observation, from 2 December 2002 to 14 November 2003. Ad libitum data was collected during 226.5 h of observation from 16 February to 3 November 2004 and during 230.5 h from 8 March to 20 August 2005.

Data analysis

Dominance

The distribution of agonistic-related interactions was used to determine dominance relationships. Kicks and kick threats were not included because these are defensive interactions. The mare that initiated the majority of agonistic-related interactions that caused a submissive response was considered to be the dominant within each dyad. Linearity of mare dominance relationships was significant (see "Results"), as tested by means of Kendall's coefficient of consistence K (Appleby 1983; De Vries 1995). Therefore, mares were ordered in a linear hierarchy by the 'I and SI' method, which finds a ranking of individuals by first minimising the number of inconsistencies and then the strength of the inconsistencies (De Vries 1998). Finally, mares were assigned an ordinal rank that increases from the bottom to the top of the hierarchy.

Measures of affiliative relationships

The K_r matrix correlation test (Hemelrijk 1990a) was used to assess the similarity of the distribution of the different types of affiliative interactions and proximity measures to choose those that would be used as measures of affiliative relationships. We constructed social matrices with the number of affiliative interactions corrected for sampling time. Time spent as nearest neighbour was computed as the mean proportion of instantaneous samples (or proportion of maps) in which each mare was nearest neighbour to another. The one body-length association index and the five body-length association index were calculated for each dyad as the average proportion of instantaneous samples (or proportion of maps) in which the two horses were each other's associates. We used proximity measures extracted from maps when performing comparisons between years because measures based on instantaneous samples were only available for 2003.

Most types of affiliative measures were positively correlated with each other, except the five body-length association index. Therefore, this association index was not included as a measure of affiliative relationships and the matrices of the different types of affiliative interactions were summed into one matrix. Affiliative relationships were assumed to be stronger among mares that were involved in affiliative interactions more frequently and spent more time in proximity (associate or neighbour).

To assess the relative contribution of each partner to an affiliative relationship, we computed an index of relative contribution of a mare A to proximity with mare B, within each dyad A–B (Crowell-Davis 1986, adapted from Hinde and Atkinson 1970) as:

$$\%\mathrm{Ap_A} - \%L_\mathrm{A} = [(\mathrm{Ap_A} \times 100)/(\mathrm{Ap_A} + \mathrm{Ap_B})] \\ - [(L_\mathrm{A} \times 100)/(L_\mathrm{A} + L_\mathrm{B})]$$

where $\mathrm{Ap_A}$ = no. approaches from A to B, L_A = no. leaves from A to B, $\mathrm{Ap_B}$ = no. approaches from B to A, L_B = leaves from B to A.

To assess the diversity of partners of each mare, we computed the diversity of partners for affiliative interactions and the diversity of nearest neighbours using an adapted version of the Shannon index. The index was divided by its maximum possible value (Pielou 1966 in Zar 1999), so that it takes values between 0 (lowest diversity) and 1 (highest diversity):

$$H/H_\mathrm{max} = (-\Sigma p_i \times \log p_i)/\log n$$

where n = no. mares in the group − 1 (no. potential partners), p_i = (no. affiliative interactions given to mare i)/

(total no. affiliative interactions given to mares) when computing diversity of partners for affiliative interactions, and $p_i =$ (proportion of time that mare i was the nearest neighbour)/(total proportion of time that mares were nearest neighbours) when measuring diversity of nearest neighbours.

Influence of individual and social factors on affiliative relationships

Kinship coefficient between each pair of mares was computed from pedigree data up to the founder animals (1937). Correlations between measures of strength and contribution to affiliative relationships and individual/social factors were assessed by the K_r matrix correlation test (Hemelrijk 1990a). Because mares that spend more time as associates are likely to interact more frequently, we also conducted K_r partial correlation tests (Hemelrijk 1990b) between frequencies of affiliative interactions and individual/social factors controlling for time spent within one body-length. The following test matrices were created: (1) age of column individuals (rows all equal); (2) dominance relationships (binary matrix: 1 = row individual dominant to column individual; 0 = the reverse); (3) kinship: close relatives via the mother (binary matrix: 1 = kin; 0 = non-kin) and kinship coefficient (based on pedigree data up to the founder animals); (4) index of relative contribution to proximity.

Spearman's rank correlation coefficient was computed to assess the relation between age, dominance rank and diversity measures. We compared the patterns of affiliative relationships between mares that were in different reproductive states within a year by means of Mann–Whitney U test. Wilcoxon paired-sample tests were performed to compare affiliative relationships of the same mares between years and affiliative relationships with mares that were in the same versus different reproductive state. Mares whose foals died soon after birth were treated as barren. To analyse changes caused by foaling, we compared affiliative relationships the month before with the month following foaling by Wilcoxon paired-sample tests. Stability of spatial relationships over the three study years was tested by the K_r matrix correlation test and Kendall's coefficient of concordance.

Means ± standard deviation and one-tailed probabilities are reported, and the cut-off for significance was set at 0.05. Standard statistical tests were performed on Statistica 5.1© StatSoft. Matrix correlation tests were executed on MatrixTester v2.2.3b© by Hemelrijk, and significance was based on a randomisation distribution of 2,000 permutations.

Results

Dominance

Despite changes in reproductive state, dominance relationships among mares did not change between years. There were two unknown relationships in 2004 because no agonistic-related interactions were observed between two pairs of mares. When constructing the dominance hierarchy, we assumed unknown dominance relationships were the same as in the remaining study years. The dominance hierarchy among mares was significantly linear in 2003 (Kendall's coefficient of consistence: $K = 0.85$, $d = 6$, $n = 10$, $P < 0.02$), 2004 ($K = 0.89$, $d = 6$, $\chi^2 = 61.06$, $df = 20$, $n = 11$, $P < 0.001$) and 2005 ($K = 0.93$, $d = 3$, $n = 10$, $P < 0.03$; Appleby 1983). Every year, dominance rank was positively and significantly correlated with age (2003: $r_s = 0.81$, $n = 10$, $P < 0.005$; 2004: $r_s = 0.86$, $n = 11$, $P < 0.003$; 2005: $r_s = 0.81$, $n = 10$, $P < 0.005$). Nevertheless, the oldest mare was not the highest-ranking mare.

Stability of affiliative relationships

Both time spent as associate and time as nearest neighbour were significantly and positively correlated between 2003 and 2004, as well as between 2004 and 2005 (Table 1). Time as nearest neighbour was also significantly correlated between 2003 and 2005, but association was not significantly correlated (Table 1). Mean time spent as associate and mean time as nearest neighbour to other mares were consistent among the nine mares present in the group throughout the whole study period (Kendall's coefficient of concordance: associate: $W = 0.81$, $\chi_r^2 = 19.5$, $df = 8$, $P < 0.05$; neighbour: $W = 0.73$, $\chi_r^2 = 17.4$, $df = 8$, $P < 0.05$).

Influence of kinship, dominance and age

Contrary to our expectations, mares with higher kinship and close relatives via the mother did not give or receive

Table 1 Correlations in time spent by Sorraia mares, *Equus caballus*, in proximity (associate and nearest neighbour) between years, as measured by the K_r matrix correlation test

	Associate		Neighbour	
	K_r	P	K_r	P
2003–2004	103	0.002	93	0.005
2004–2005	126	0.001	93	0.002
2003–2005	39	0.12	79	0.005

2003–2004: $n = 10$; 2004–2005: $n = 10$; 2003–2005: $n = 9$

Table 2 Correlations between age, dominance, kinship and affiliative relationships, as measured by the K_r matrix correlation test and its partial form $\tau_{K_{rxyz}}$

	2003							2004		2005	
	AIG	AIR	AIGP	AIRP	ICP	IA	NN	IA	NN	IA	NN
Age	45	63	−0.02	−0.003		112*	62	51	52	−17	−35
Dominance	20	−61*	0.26*	−0.21	97**						
Close relatives	−11	15	−0.14	0.08		12	16	−9	4	2	−8
Kinship coefficient	21	21	0.08	0.09		−8	16	8	−12	33	16

Values of K_r are presented for all correlation tests except for partial correlations AIGP and AIRP, where values of $\tau_{K_{rxyz}}$ are presented

AI Affiliative interactions (*G* given, *R* received, *P* partial correlation controlling for association within one body-length), *IA* association index, *NN* nearest neighbour, *ICP* index of contribution to proximity

* $P < 0.05$, ** $P < 0.01$

higher frequencies of affiliative interactions and also did not spend more time in proximity to each other in any year (Table 2).

Affiliative interactions were received significantly more often from dominants, as predicted, but this correlation was no longer significant when time spent in association was partialled out (Table 2). Affiliative interactions were not given to subordinates more frequently than in the opposite direction. However, when time spent in association was partialled out, affiliative interactions were given to subordinates significantly more often (Table 2). Moreover, the significant positive correlation between dominance and the index of relative contribution to proximity indicates that dominants contributed most to proximity relative to subordinates (Table 2).

Mares did not initiate higher frequencies of affiliative interactions with older females and also did not receive lower frequencies of affiliative interactions from them (Table 2). Females spent significantly more time in association with older mares only in 2003 (Table 2). Diversity of partners for affiliative interactions was not related to age ($r_s = 0.07$, $n = 10$, $P > 0.05$). The relationship between age and diversity of nearest neighbours was contradictory between years. In 2003, older mares had significantly lower diversity of nearest neighbours, as expected (Table 3). By contrast, in 2004 and 2005, diversity of partners as nearest neighbour increased with age, but only significantly so in 2005 (Table 3).

Influence of reproductive state

Frequencies of affiliative interactions given and received from mares in the same reproductive state were not higher than those given or received from mares in different reproductive state (Wilcoxon paired-sample test: given: $T = 11$, $n = 10$, $P < 0.1$; received: $T = 17$, $n = 10$, $P > 0.05$). Mares spent significantly more time in proximity to females that were in the same reproductive state as them in 2003 (associate: $T = 8$, $n = 10$, $P = 0.025$; neighbour: $T = 7$, $n = 10$, $P < 0.025$; Fig. 1) but not in 2004 (associate: $T = 30$, $n = 11$, $P > 0.05$; neighbour: $T = 31$, $n = 11$, $P > 0.05$; Fig. 1). In 2005, mares spent significantly more time having mares in the same reproductive state as nearest neighbours ($T = 8$, $n = 10$, $P = 0.025$; Fig. 1) and also tended to have them as associates ($T = 13$, $n = 10$, $P < 0.1$; Fig. 1).

Table 3 Correlations between age and diversity of partners as nearest neighbours, as assessed by the Spearman's rank correlation coefficient

	Mean ± SD	Range	r_s	*P*
2003	0.93 ± 0.04	0.88–0.99	−0.89	<0.01
2004	0.81 ± 0.08	0.70–0.91	0.47	<0.1
2005	0.84 ± 0.07	0.70–0.92	0.60	<0.05

2003 and 2005: $n = 10$; 2004: $n = 11$

From the month before parturition to the month following parturition, both the mean time spent by mothers within one body-length of other mares and the mean time spent within five body-lengths of other mares decreased significantly (one body-length: $T = 1$, $n = 7$, $P < 0.025$; five body-lengths: $T = 0$, $n = 7$, $P = 0.01$).

Mares with foals initiated significantly lower frequencies of affiliative interactions, spent less time in proximity to others and contributed less to proximity than barren mares, in 2003 (Table 4). In 2004 and 2005, mares with foals spent significantly less time having other mares as nearest neighbours and tended to spend less time as associates than barren mares (Table 4). During the latter year, mares with foals spent significantly less time as nearest neighbours to others (Table 4). However, diversity of partners was not lower in mares with foals than in barren mares in any year (Table 4).

Six mares experienced different reproductive states throughout the study period. When these mares had foaled, they spent significantly less time as nearest neighbours to

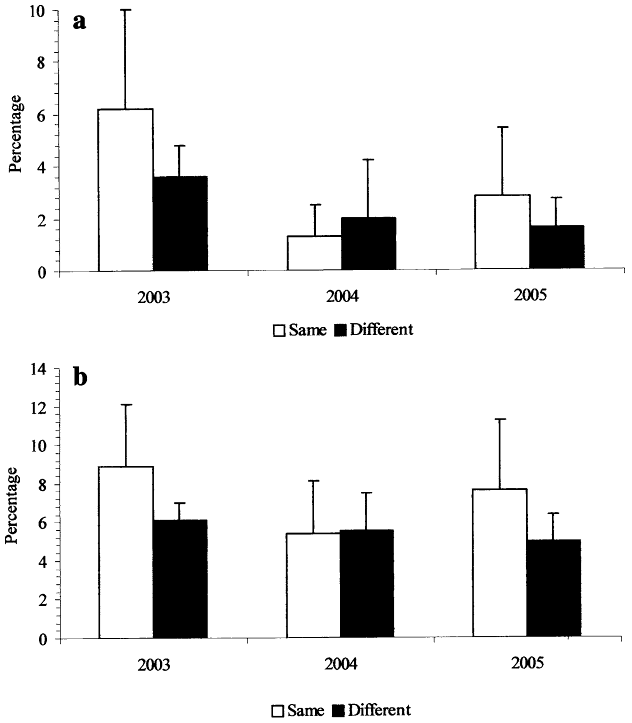

Fig. 1 Percentage time spent by Sorraia mares, *Equus caballus*, in proximity (mean ± SD) to mares in the same reproductive state and mares in different reproductive state: **a** associate; **b** nearest neighbour

Table 4 Differences in the strength of affiliative relationships, contribution to proximity and diversity of partners between barren mares and mares with foals within each year, as assessed by the Mann–Whitney *U* test

Affiliative measure	2003		2004		2005	
	U	*P*	*U*	*P*	*U*	*P*
Affiliative interactions given	21	0.01				
Affiliative interactions received	15	0.1				
Association index	19	0.05	24	<0.1	20	<0.1
Nearest neighbour to mares	21	0.01	22	>0.05	21	0.05
Mares are nearest neighbours	21	0.01	30	0.0025	24	0.005
Index contribution to proximity	21	0.01				
H affiliative interactions	16	<0.1				
H nearest neighbour	4	>0.05	22	>0.05	6	>0.05

All tests are one-tailed and the null hypotheses state that barren mares have higher scores on affiliative measures than mares with foals

2003: $n_{\mathrm{Barren}} = 7$, $n_{\mathrm{Foal}} = 3$; 2004: $n_{\mathrm{Barren}} = 5$, $n_{\mathrm{Foal}} = 6$; 2005: $n_{\mathrm{Barren}} = 6$, $n_{\mathrm{Foal}} = 4$; *H* diversity index

females ($T = 0$, $n = 6$, $P = 0.025$; Fig. 2) and spent less time having females as nearest neighbours, than when they had been barren ($T = 0$, $n = 6$, $P = 0.025$; Fig. 2). However, mean time spent as associates to other mares was not significantly different ($T = 4$, $n = 6$, $P > 0.1$; Fig. 2). Moreover, diversity of partners as nearest neighbours was not lower when the mares had foaled than when they had been barren ($T = 3$, $n = 6$, $P = 0.1$).

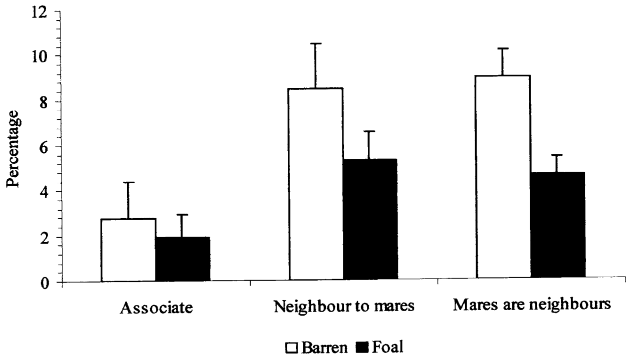

Fig. 2 Percentage time spent by six mares (mean ± SD) as associate, time as nearest neighbour to other mares and time spent having other mares as nearest neighbours, depending on reproductive state

Discussion

Affiliative relationships among Sorraia mares were relatively stable over the 3-year study period, especially between consecutive years. Tyler (1972) and Van Dierendonck et al. (2004) reported bond stability over 3-year study periods, but Kimura (1998) found more unstable bonds that suffered seasonal changes in Yururi horses (Kimura 1998).

The finding that close relatives via the mother did not develop stronger bonds is consistent with those of Van Dierendonck et al. (1995) and Heitor et al. (2006a), but not with the observations of Tyler (1972) and Monard and Duncan (1996). The separation of young females from their mothers and older sisters from 9 months to 3 years of age may preclude individual recognition later on and cause disruption of previous family bonds. Contrary to the findings of our previous study (Heitor et al. 2006a), mare dyads with higher kinship coefficient did not form stronger affiliative relationships. These differences between studies may be related to changes in group composition and reproductive state of the mares. In the previous study, only one mare had foaled and the foal was born late in the study period (Heitor et al. 2006a). In the present study, the fact that a larger number of mares foaled in each year may have reduced the influence of kinship on affiliative relationships. In accordance with the reports of Van Dierendonck et al. (2004), affiliative relationships tended to be stronger among Sorraia mares that were in the same reproductive state. As foals begin to interact with each other and their mothers maintain proximity to them, mares in the same reproductive state may end up spending more time in proximity (Van Dierendonck et al. 2004).

Older females did not initiate lower frequencies of affiliative interactions nor did they receive higher frequencies of affiliative interactions than younger females. Keiper and Receveur (1992) documented a negative correlation between frequency of affiliative interactions initiated and age, but foals were included in their analysis. In our study, mares spent more time as associates to older females and diversity of partners decreased with age only in one of the study years. Therefore, our findings provide little evidence that Sorraia mares disengage from social relationships with increasing age. However, effects of age would be best examined by a longitudinal study, to control for the effects of individual differences and temperament on social behaviour.

After foaling, the strength of affiliative relationships with other mares decreased as predicted, but diversity of partners was not lower in mares with foals than in barren mares. Changes in affiliative behaviour after foaling have also been reported by other authors and are implicated in foal protection and development of the bond between dam and foal (Estep et al. 1993; Van Dierendonck et al. 2004). Social isolation is important for imprinting and individual recognition between dam and foal, thereby preventing foals from bonding with other horses in the first few days after birth (Estep et al. 1993; Van Dierendonck et al. 2004). In addition, mares with foals tend to become more aggressive (Waring 1983; Klimov 1988; Van Dierendonck et al. 1995, 2004), which could cause other horses to avoid approaching them. However, affiliative interactions received by mares with foals did not significantly change either in our study or in that of Estep et al. (1993). This result suggests that mothers are mainly responsible for social disengagement rather than group members.

Dominant mares contributed the most to affiliative relationships with subordinates, as predicted. The dominance hierarchy may inhibit low-ranking mares from initiating affiliative interactions with higher-ranking mares (Wells and Von Goldschmidt-Rothschild 1979) due to the increased probability of receiving agonistic interactions from them (Heitor et al. 2006a). Moreover, subordinates may leave dominants more often than they are left by dominants, due to agonistic interactions received from them, thereby contributing less to proximity. Consistent with these findings, Camargue horses directed approaches and friendly contacts mostly down the hierarchy (Wells and Von Goldschmidt-Rothschild 1979), and mutual grooming was most often initiated by the dominant of the pair in Highland ponies (Clutton-Brock et al. 1976). However, Tyler (1972) noted that mutual grooming bouts were most often initiated by subordinates in New Forest ponies (Tyler 1972). The fact that foals and yearlings were included in her analysis may account for this contrary result.

Dominance relationships were stable over the study period and mares with foals did not rise in rank, which is in accordance with the reports of Keiper and Sambraus (1986) and Estep et al. (1993). As reported in other studies on horses, dominance rank was positively correlated with age (e.g. Tyler 1972; Clutton-Brock et al. 1976; Wells and Von Goldschmidt-Rothschild 1979; Van Dierendonck et al. 1995; Sigurjónsdóttir et al. 2003; Heitor et al. 2006b), but the highest-ranking mare was not the oldest in the group (Sigurjónsdóttir et al. 2003; Van Dierendonck et al. 2004). The absence of the oldest mare from the herd before this study and possibly decreased fighting ability caused by senescence may both have contributed to her lower position.

Overall, reproductive state was the factor that had the most consistent influence on affiliative relationships among Sorraia mares and may have obscured the effects of kinship. Alternatively, kinship effects could have remained undetected due to the small group size or the relationship between kinship and bonds found in the previous study (Heitor et al. 2006a) could have been a spurious one. Therefore, further investigation should be conducted in other Sorraia horse groups with different sizes and composition kept under diverse social and environmental conditions before conclusions regarding the influence of kinship can be drawn.

Acknowledgments We thank Dr. João Costa Ferreira for permission to conduct this study at Alter studfarm and Dr. Maria do Mar Oom for providing the kinship data. We are also indebted to Dr. Charlotte Hemelrijk for providing her computer program. F. Heitor was supported by a Doctoral Fellowship granted by the Fundação para a Ciência e a Tecnologia (SFRH/BD/8792/2002).

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