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Research Article

The Behaviour of Stallions in a Semiferal Herd in Iceland: Time Budgets, Home Ranges, and Interactions

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A permanent herd of Icelandic horses with four stallions and their harems was studied for a total of 316 hours in a large pasture (215 ha) in May 2007 in Iceland. Interactions between stallions of different harems and other aspects of the horses' behaviour were studied. One stallion and nine horses were introduced into the pasture prior to the study to examine the reactions of the resident stallions to a newcomer. The stallions spent significantly less time grazing than other horses and were more vigilant. Home ranges overlapped, but harems never mixed. The stallions prevented interactions between members of different harems indirectly by herding. Generally, interactions between resident stallions were nonviolent. However, encounters with the introduced stallion were more aggressive and more frequent than between the other stallions. Here, we show that four harems can share the same enclosure peacefully. The social network seems to keep aggression at a low level both within the harems and the herd as a whole. We encourage horse owners to consider the feasibility of keeping their horses in large groups because of low aggression and because such a strategy gives the young horses good opportunities to develop normally, both physically and socially.

1. Introduction

Wild and feral horses form herds composed of harems and bachelor groups. Harems are defended by one or more stallions against other males [1], while bachelor groups consist of young stallions that have not yet managed to form their own harems. Usually one to three adult females and their offsprings make up the harem [2–4], while more numerous harems have been observed in some cases; the highest number recorded is 26 [1]. The stallion does not defend a territory but keeps his harem within a certain home range [5]. Both female and male offspring disperse from their natal group when sexually mature [6, 7]. Adult mares have been seen to change harems in feral populations (see [8]). but many stay in the same harem all their lives such that breeding group membership is very stable [9]. Changing harems will often mean some fitness loss for the mares since drifting mares are harassed and herded more often by the stallions [10]. This mating system, that is, female defence polygyny, is remarkably stable in different habitats where domestic or feral horses live [1].

Traditionally predation risk and distribution of resources are considered to be the fundamental factors behind the evolution of this mating system [11]. Thus, when females form groups because of increased survival, the males can use that to their advantage and can defend the females [12]. Linklater et al. [13] and Rubenstein and Nunez [10] argue on the other hand that social bonding is more likely to explain the prevalence of the mating system because social bonds between unrelated females both increase birth rate and survival [9] and decrease male harassment.

Home ranges vary in size with season and between populations. Their sizes correlate with availability of resources, but not with group size [11]. Minimum spacing between the

harems is maintained by the stallions. When harems get close to each other, the stallions approach each other and display. The interactions escalate to mild fights on some occasions. This behaviour has been documented in populations living in a variety of environments. Interactions between horses from different harems, other than stallions, seem to be very rare or absent [8, 14, 15].

Environmental conditions, time of year, level of competition for resources, and age composition of the groups have been found to be important variables deciding time budgets of feral horses. Grazing has been reported to take 56–86% of the time, resting standing and lying down 9–35%, standing alert 6–20%, moving 3–13%, allogrooming and playing 2-3%, and other behaviour 2–4% [2, 16].

Here we report on a study of a semiferal herd in Iceland. The only breed found on the island is the Icelandic horse. The breed has been isolated since the time of settlement (870 A.D.) and shows adaptations to the harsh climate and the rough terrain [17, 18]. No horses are allowed to be imported to Iceland because of reduced immunity of the breed [19, 20]. Many horses are kept outside all year around, but for winter, supplementary feeding is now required [20]. Often, the horses are kept under conditions with little human interference. Adult mares, foals, subadults, and gelding are in some places kept in large herds consisting of hundreds of individuals over the summertime in extensive grazing areas. Thus the young horses have good opportunity to develop normal equine social skills [21, 22]. However, free roaming of stallions is prohibited and only in exceptional cases do harem keeping stallions share the same enclosure.

The aim of this research was primarily to study the behaviour of stallions in a semiferal herd. Interactions between the stallions were analysed, their home ranges were mapped, and their time budgets were compared to the other horses. We also wanted to see how residency of the stallions affected their behaviour. This was done to deepen our understanding of the social structure of horse groups and to get information about the feasibility and possible advantages of keeping horses in large groups.

2. Methods

2.1. Study Area and Animals. The study was conducted at the farm Sel in East-Landeyjar in the south of Iceland. Horses have been kept there in a 215 ha enclosure with very limited human contact for approximately 30 years, giving a herd with close to natural social organization. Occasionally old stallions have been replaced with new ones. In the autumn, male foals and most of the fillies have been removed (some fillies had been left in the pasture to serve as replacements for the ageing mares). Replacement foals were given anthelmintics once in their first year, but were otherwise not handled. Foals born late in the summer stayed over the winter in the herd and were removed the following autumn. In addition, the horses were gathered weekly during August and September, for sampling blood from some of the breeding mares. The blood sampling, which was done for commercial purposes, was done by veterinarians.

Table 1: Composition, size of the harems, and age and residency of the four stallions.

Harems	Total number	Adult mares	Immature horses (female/male)	Age and residency (in years) of the stallions
H1	20	16	3 (1/2)	13–2
H2	31	21	9 (8/1)	17–8
H3	30	23	6 (3/3)	20–15
H4	12	8	3 (3/0)	13–8

The land in the enclosure is productive, native grassland, flat with small tussocks. The dominant species are the grasses *Agrostis capillaris*, *Agrostis vinealis*, *Poa pratensis,* and *Anthoxanthum odoratum* and the sedge *Juncus arcticus*. A large ditch (3 m wide, 1500 m long) runs along part of the west border and in the middle there is a manmade shelter (turf). In the wintertime the horses are fed supplementary hay.

In the enclosure, four resident stallions (St 1–4) had divided the herd into four harems (H1–H4, see Table 1). The total herd consisted of 93 adult mares and subadults (3yrs and younger). In addition, 42 foals were born shortly before and during our observations.

One day before regular observations started, an additional group, a young stallion with 6 subadult mares, three adult mares, and a foal, were put into the enclosure. Six of the mares and the foal joined H2 within 30 minutes, one subadult joined H3 within one day and these eight horses became members of the resident harems. These horses are included in the respective harems in Table 1. Two adult mares and the young stallion were removed from the pasture one week later.

2.2. Observations and Mapping. The four harems (H1–H4) were observed for 81 (H1), 77 (H2), 77 (H3), and 81 (H4) hours, respectively, on 18 days between the 9th and the 31st of May 2007. This was done during 5-hour shifts (with exceptions) during daylight hours organized in a balanced way between 04:00 and 00:00. Data was recorded in field books and binoculars were used when needed. Interactions between stallions were sometimes videotaped. Two persons observed H1 and H2 and two other persons observed H3 and H4. Interobserver reliability was used to assess the degree to which different observers recorded. Two persons were on guard each shift, observing one harem each. The observers approached the horses quietly and sat on the ground, taking care not to disturb or interact with the horses. All the horses were easily recognized by the observers, either by colour, special markings, or freeze brand marks on their backs.

For time budget estimates different behaviour (see Table 2) was scored by *instantaneous scanning* [23]. For the stallions it was done every 10 minutes during all the shifts, (N = 486, 462, 462, and 486 for St 1–4, resp.) but less frequently for the other horses (N = 296, 268, 319, and 259 for H 1–4, resp.). The part of the pasture, that each harem had stayed on during every hour was marked on a map. This was done by hand by rough estimation since no GPS

Table 2: Behavioural classes (for detailed descriptions of these behavioural acts see [25]).

(1) Time budget analyses	(2) Interactions between stallions
Grazing, standing resting, standing alert, lying down, walking, herding*, sexual behavior, allogrooming (other behaviours were pooled)	(A) Aggressive and violent interactions: fighting (neck wrestling, boxing, and dancing where both are upright), attack where one lunges on the other, aggressive bites, aggressive chase, foreleg strike, stamping (B) Nonviolent interactions: approach with arched necks, parallel walk, posturing, marking

* Applies to stallions only.

measurements were taken. Changes in group compositions were also noted based on individual recognition of the horses.

The method *all occurrences of some behaviour* [23] was used to collect data on interactions between stallions. The ethogram is listed in Table 2. Other interactions between horses of different harems were very few and are described more generally in the results. Nature and frequencies of interactions between members within harems are published elsewhere [24].

2.3. Analyses. Chi square tests were applied to the time budget data to test if proportions of behaviours differed between stallions and the other horses. We compared the behaviour of the stallions in the same way when analysing their interactions with respect to residency in the pasture and location of their home ranges.

The home ranges were estimated by giving each map 4 points on an ArcGis map. The likelihood of finding the harem within the home range is then shown by fading colours from red (10x or more) to yellow (seen once) and the core area defined as the most red part of the home range. Statistics and computations were done with the help of Excel.

3. Results

3.1. Time Budget. An overall average time budget for the horses in the pasture is shown in Figure 1.

The horses spent most of their time grazing (77%). The four stallions spent proportionally less time grazing (χ^2 = 135.4, $P < 0.001$) and more time standing than the other horses (χ^2 = 601.9, $P < 0.001$) (Figure 2). This was due to proportionally much higher frequency of standing alert while standing resting as not different between the stallion and the other horses (χ^2 = 2.93 ns).

3.2. Home Range, Herding Rate, and Changes in Group Compositions. Although the home ranges overlap by ca. 20%, the harems never used the same area at the same time and the horses in one harem hardly ever mixed with horses from another harem. The sizes of the home ranges estimated in this way were 93, 54, 65, and 49 ha for H1, H2, H3, and H4 respectively (see Figure 3).

The herding rates differed between the stallions. Size of the home range, number of mares and experience clearly matters. The stallion which had the largest home range, St1, herded his band 84 times (1.04 per hour), while St4, who had the smallest home range, was only seen herding 5 times in total (0.06 per hour). The other stallions were seen herding 56 and 50 times, respectively (see also [24]). When the numbers of mares in the harems are considered, the difference between the stallions is less but nevertheless of interest. Although St1 herded his mares 5.2 times on average compared to the average rate of 2.6, 2.2, and 0.6 time for St2, St3, and St4, respectively, he mounted his mares less frequently (0.8 times on average per mare compared to 1.3,

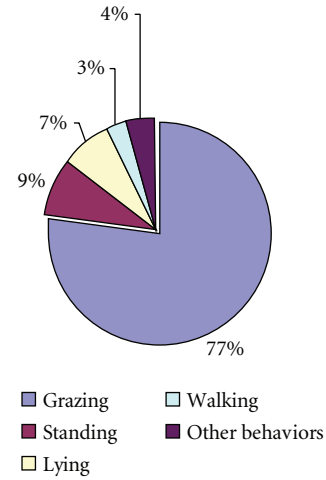

Figure 1: Time budget of all the horses in the herd.

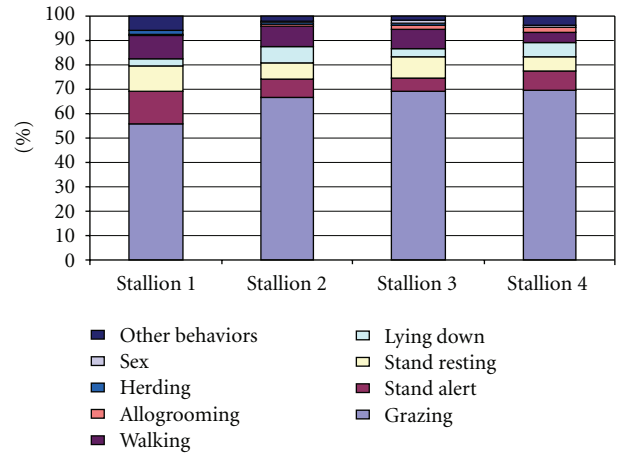

Figure 2: Time budget of the four stallions.

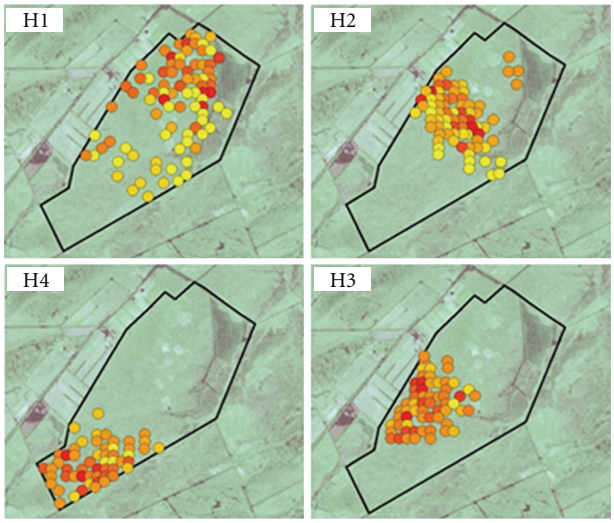

Figure 3: Location of the four harems in the pasture. The horses are most often found where the reddest spots are shown.

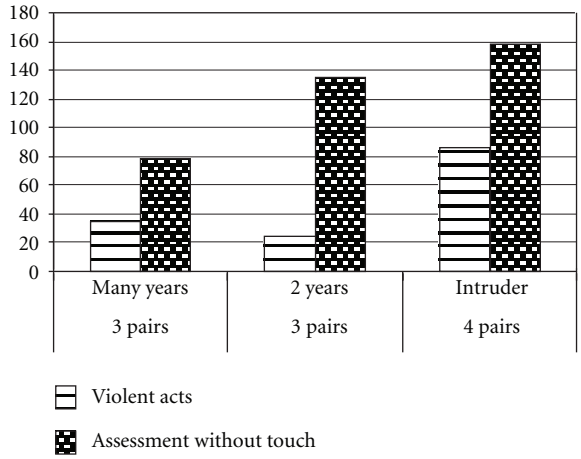

Figure 4: Number of behavioural acts shown during encounters between pairs of stallions that have shared the same pasture for different length of time, split into violent and nonviolent acts.

1.9, and 1.4 for St2, St3, and St4, respectively, see [24]). This is probably due to his lack of experience and large home range.

Only three mares changed harems. One adult mare moved without being chased or threatened on the 25th of May from H1 to H2. One young mare was driven from her natal group, H4, on the 19th of May by the stallion (St4) and was accepted the following day into H1. One young mare was excluded from H2 on the 23rd of May by St2 and was on her own positioned between H2 and H3 until the end of the observations (when checked a month later, she had been accepted into H3).

3.3. Interactions between Members of Different Harems. A total of 112 encounters between individuals from different harems were observed during the study. Most, or 81.5%, occurred between two stallions (including the newcomer), 8.5% involved aggressive behaviours of stallions against mares and subadults from other bands, and 10% of cases involved interactions between subadults mares from two bands.

3.3.1. Interactions between Stallions. The average rate of close encounters (distance less than one horse length) between the resident stallions was 0.30 events per hour. St2 had the highest frequency (0.44/hour) and St4 the lowest (0.14/hour). St2 showed most often the initiative to approach other stallions (25 cases of 34 encounters, which is a significantly higher proportion than for the other stallions ($\chi^2 = 70.17$, d.f. = 1, $P < 0.001$), while St1 was relatively the least initiative (7/31). The oldest stallion who had been in the pasture for the longest time, St3, and St4 who had the smallest band were less active (18 and 11 encounters, resp.) than the others. As expected, the resident stallions interacted proportionally more with their neighbours than with other stallions ($\chi^2 = 88.7$, d.f. = 1, $P < 0.001$).

When the encounters are split into different behavioural classes (see Table 2) the data shows that the frequency of nonviolent acts (374), that is, assessment without touch, was much more frequent than violent acts (152). In Figure 4 the behavioural acts are shown with respect to how long each pair has been sharing the same pasture.

Not surprisingly, the newcomer was frequently, or in total 36 times, challenged by St1 and St2, who had home ranges located to the area where he spent most of his time while in the pasture. He only had three encounters in total with the other two stallions. On average he had an encounter with St1 or St2 once per hour during the time he was in the pasture which is much higher than between neighbouring resident stallions (St4/St3: 0.07, St3/St2: 0.12, and St2/St1: 0.35 per hour). Also, encounters between the newcomer and the resident stallions were significantly of the more aggressive nature than between the resident stallions (Figure 4, $\chi^2 = 161.7$, d.f. = 1, $P < 0.001$). Residency is clearly an important variable as can be seen in Figure 5 which shows the behaviour of the most active stallion, St2, against both his resident neighbouring stallions and the newcomer (intruder). His interactions were most violent against the newcomer, but he also interacted much more with his neighbour St1 than St3 which is probably due to shorter residence time of St1 in the pasture.

4. Discussion

The results presented here show many similarities with results from studies on feral horses [2] although no bachelor groups were present. Thus, three of the four stallions herded the harems/bands every hour or every other hour preventing the adult mares and the subadults to interact with members of other harems and keeping them within the home range. During our observation time we witnessed two stallions expel young mares from their harems with fierce aggression and later that summer we witnessed two more cases within the herd. Clearly, the behaviour of the males is typical of

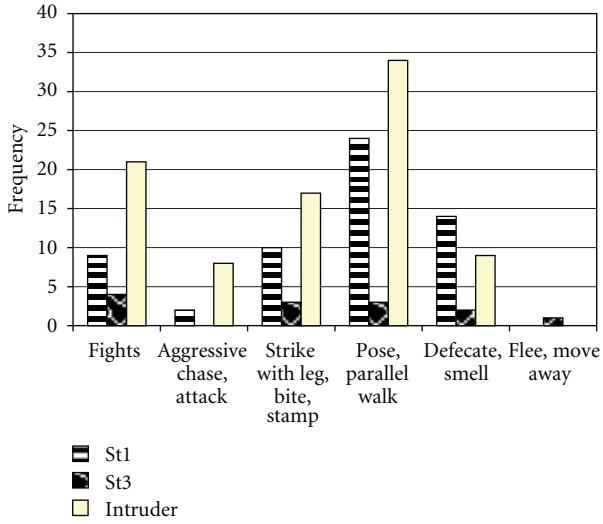

Figure 5: Frequencies of different behavioural acts between St2 and three stallions (his neighbours and the newcomer/intruder).

what has been described for feral horses when natal dispersal occurs [6]. The hierarchies of the harems were less linear and rigid than in nonstallion groups [21, 24] just as Feist and McCullough [15] reported in their study on 44 bands of feral horses in USA.

Time budgets for the studied herd showed that the horses spent on average 77% of their time grazing which is similar to the grazing time measured in the late summer and fall for Icelandic horses but less than in the middle of the summer in Iceland [16]. At the time of the study, in the spring, some of the horses were rather thin after the winter and almost all the mares were already lactating or close to having a foal. Acquiring enough nutrients was therefore a high priority for them. Similar grazing time has been shown in other areas during harsh times [8, 14, 26]. The stallions spent significantly less time grazing and more time standing alert than the average harem member. This is expected since they need to keep the harem within the home range and be aware of the time when the mares become sexually receptive after foaling.

Home ranges overlapped considerably and all harems spent more time close to the water than in other parts of the home ranges. The same behaviour has been described for other populations [27]. The pasture was adequate for keeping the horses in good condition from spring till late in the autumn and during the observation time there were no signs of competition for grazing areas. Thus, the home ranges seemed to satisfy the nutrient requirements of the horses during the growing season.

Interactions between members of different bands were very few, except between stallions. The low number of interactions between other horses is mainly due to the herding behaviour by the stallions preventing the harems to come too close to each other. The herding rate was low compared to some other studies [8] but similar to Feh's study [28] on Camargue horses. However, comparison is difficult because of high female/male ratio and lack of bachelors in this study. In this herd the pressure to defend mares from other stallions is less than in feral herds because of the absence of bachelors and secondary males (in multistallion groups). The stallions communicate to great extent by scent through urine and dung but dung piles were numerous in the pasture.

The low sex ratio can also explain why direct interactions between the stallions are relatively infrequent in spite of having overlapping home ranges. In Franke-Stevens [8] study on feral horses (60 horses in 12 harems on 172 ha pasture), the resident stallions interacted 0.88 times/hour in the summer time and 0.48 in the wintertime compared to 0.30 on average in this study. In the study by Linklater et al. [13] the stallions in the single stallion harems interacted 0.50 times per hour. As expected, neighbours interacted more than others in this study. Length of time the stallions have been together in the pasture seems to influence their interaction rates (Figure 4). Thus, encounters with the newcomer were significantly more frequent than with the other stallions, and the stallion that had been in the pasture for a shorter time (St1) than the other resident stallions was approached by his neighbour (St2) relatively frequently (Figure 5). For the stallions that have been together for the longest time, it is probably often sufficient to leave dung and urine markings instead of engaging in direct interactions. Berger [14] argued that marking is a significant factor in maintaining the organizational systems of feral horses. Rubenstein [29] has shown that the scent is an honest signal and serves to communicate information about the quality and presence of males.

When the interactions between stallions are analysed in more detail it is clear that most behavioural acts which the stallions exhibit during interactions were nonviolent. Aggressive chases and fights were relatively rare. This is in contrast with what Berger [14] found but in agreement with most other studies [2]. For instance, Rubenstein and Hack [30] analysed 231 encounters and of those only 19% resulted in violent contests. As expected, interactions with the newcomer were more aggressive. The horses' behaviour is a good example of assessment strategies, where assessment of opponents is a part of the behavioural sequence and withdrawal of the one with a smaller RHP (resource holding potential) is the rule [29, 31].

5. Conclusion

Our study shows that the behaviour of semiferal horses in a herd where stallions with harems are kept in a relatively large and productive pasture (ca. 2 ha/horse) is similar to that found in feral and semiferal herds living in larger areas. Also, when the stallions have shared the same pasture for many years they clearly recognize each other [32, 33] and rarely interact. They avoid the cores of the home ranges of other stallions and seldom fight. This is in accordance with findings of Cozzi et al. [34] which showed that horses show highly developed skills in dealing with conflict by reconciling and appeasing in a similar way as has been described for apes

[35], dogs [36], and birds [37, 38]. Thus, horses seem to realize their position in the hierarchy and the social network which characterizes their group. Keeping horses in large herds where they have the opportunity to mix with horses of all ages and both sexes allows them to develop their social skills when young. More research and deeper understanding of the consequences of not giving horses such opportunities is needed [22, 39, 40]. In this herd the stallions kept their harems separate from others and their interactions were in general nonviolent. It is concluded that it can be a good management strategy to keep horses in large herds with harems, provided good tempered stallions are chosen and the horses have good access to water, shelter, and sufficient space.

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