

Factors Affecting the Harem Formation Process by Young Misaki Feral Stallions

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ABSTRACT. For the past 12 years, a study was conducted in the Misaki area (southern Kyushu Island, Japan) to investigate young males form new harems, how they acquire the mares and the factors affecting the process of new harem formation. Young males formed new harems between the ages of 3.8 and 7.6 yr, and 93% of these new harem groups were formed at the beginning of the breeding season. The most common way (87%) for young males to form a new harem was by acquiring wandering mares which had separated from their groups, whereas 13% stole unstable mares from established bands. The fact that all young males obtained harems the new at an early age, with an average age of 5.2 yr (n=15) could be explained high female biased sex ratio (3:1), and great number of wandering mares per stallion (2.5:1). At the time new harem groups were formed, aggression, fighting or such behavior as active herding or driving mares was not observed among stallions because the "unstable" mares were most likely to be abducted by stallions.—**KEY WORDS:** feral horse, harem formation, social organization, young male.

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According to recent reviews of the social organization of equids, feral horses develop stable social groups consisting of one stallion, one to several adult mares and their offspring [1, 21]. Young stallions become sexually mature by 2 years of age [17], but are not treated as rivals by adult stallions until they are three years old [26]. Young male horses in the Misaki area experience three distinct stages from birth until harems formation. The first stage begins at the birth of the young males and ends when they separate from their natal band or mothers and do not return and is called separation stage [13]. The second stage, in which the young males commits more time to social play than to aggressive interactions, starts after the separation and is called the developmental stage [14]. The third stage, in which the young males usually attempt to herd various mares before eventually succeeding in establishing a hared of their own through joining wandering female groups more than association with other social groups and is called the pre-harem formation stage [16]. Commonly, the wild stallions formed harem groups at the age 6–8 years old in wild horses [2]. When harem is formed, there is strong fighting between the stallions. Because the older males with fewer reproductive opportunities remaining, might benefit more by fighting to obtain harems rather than by waiting for wandering mares. On the other hand, Misaki horses made harem at more younger ages which ranged between 4–6 years [9]. Further, there is little fighting. Therefore, we examined detail what the factor affecting the age of the harem formation in Misaki area. At the time of harem formation, the number of mares per family is an important sociological measures [19]. However, the changes in harem size may be influenced by some factors such as rainfall

[18], presence or absence of a foal in the herd [23], or the testosterone level of the harem stallion [15]. In Misaki area, most stallions formed harem groups with smaller numbers of mares, with an average of 2 [9]. These smaller harems would tend to be more stable than the largest and so these mares tended to be associated with the same stallions every year [6]. Although Misaki horses is wild animals, the male/female ratio is lack of balance. This unevenness in adult sex ratio due to all males other than males to be stallions have been castrated in their third autumn from 1973 to 1979 and left together with other horses on the pasture [4]. How are they adapted to these conditions? to answer this question, we investigated the process of harem formation.

The aim of this study was to determine 1) the season and age of young stallions at the beginning of harem formation, 2) factors affecting the age and process of the harem formation, and 3) the ways in which young Misaki stallions acquire their new harems.

MATERIALS AND METHODS

Study Location: Cape Toi, approximately 5 km² in area, is located at the southeastern end of Kyushu Island. There are two hills in the center of the Misaki range: Komatsugaoka Hill (287 m above sea-level) and Ogiyama Hill (295 m above sea-level). Numerous large and small valleys are found throughout the range. They divide it into two areas: the Komatsu and Oogi areas, which are similar in size, as well as in topographical and ecological characteristics. These hills are covered with various kinds of native grasses, and other areas of the range are mostly occupied by artificial forests with Japanese cedars and a variety of corses [10]. The climate is moderate, with temperatures ranging from 4°C to 15°C in winter and from 24°C to 31°C in summer. June and July are rainy periods.

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Fresh water ponds are plentiful in the Misaki range. Generally, the warm climate and abundant rain provide luxuriant vegetation in the summer.

Study animals and population characteristics: Misaki horses have been living freely in the range since 1697. Management practices are minimal and horses are only fed a small amount of supplementary grass during severe winters. The range has been patrolled daily in order to record any births, deaths or accidents. The population dynamics of the horses and individual reproductive success and home range of each animal have also been recorded. This study was conducted from January 1986 to March 1998 and we observed 15 young Misaki males during this time. Every young male has been recorded individually on sketch maps since 1986. Almost all of the horses spent the majority of their time on the grasslands from early April to late September. During other seasons, they lived in the forests or in the weedy grasslands that face south. Individual horses were identified by their unique markings, such as coat color, sex, body size, markings and age, and were recorded as foal, yearling, immature (2 to 3 yr old) and adult. Each animal was considered to be in only one age class throughout a particular calendar year, and the age of all animals of the population was recorded in the form of birth date and numbers branded on their hips. The horses could be observed on foot from a distance of 5–15 m without affecting their normal behavior because they were accustomed to the presence of humans.

Field observation of social behavior: Observations were made once a week during the study period. Most of the males were found on the top of the mountain, during the breeding season (from the end of March until the end of August). Detailed observations of each group's social behavior were made to determine whether young males were allowed to remain within the group or enter another. During the non-breeding season (from September until the beginning of March) locating and observing the horses was not easy because most of the groups had separated into small bands and then moved into the forests. Data on the behavior and movements of the young males were gathered by traversing routes through the study area on foot and by car. When the known young males were sighted in the field, behavioral data were collected by focal sampling and focal group sampling techniques. This procedure involved continuous observations and recording of each horse's specific interaction within a group during the sampling period. The amount of time that each horse stayed in a particular group was recorded by observing the horse's branded number. Each time horses were observed associating with a particular group, the membership of that group was checked to see if it was the same or different. Moreover, twenty-nine mares (age ≥ 2 years) were observed continuously during this study to investigate their lifetime stability and its effect on the harem formation process. This was the method used to collect data about young males and the mares during this study.

Definition of the lifetime stability and consort

relationship stability between the harem stallions and the mares: The lifetime stability of individual mares was defined as the ratio (%) of the number of years in which the mares has a stable consort relationship with her harem stallion to the total number of years after age 2 years. The consort relationship between a harem stallion and a mare was defined as stable if a particular mare was seen with the same stallion at least 8 times in the breeding season of one year from early April to late August (at least once in April and August, and at least twice in May, June and July). Hence, all the mares with a lifetime stability of 0% were a young mares between age 2 and 3 year-old showed no consort relations with any stallions because they were young sexually mature and looking for particular stallions. However, the mares who showed a lifetime stability below 59% seemed to remain only transiently for a few hours or days with a particular stallion in order to mate during estrous. The age of such wandering mares ranged between 4 and 7 years. In opposite, the mares who showed a lifetime stability of less than 79% tended to change their partner at intervals of 1 to 2 years and the age of these mares ranged between 4 and 21 years. Actually, the mares with a lifetime stability of over 80% continued stable consort relations with the same stallions over 4 to 10 years [8].

Definition of wandering mare: A wandering female either young females separated from their natal band at adolescence or adult mares who had separated from their harem bands after their stallion had died [16].

Statistical analysis: The results are expressed as the mean \pm s.d. Fisher's Protected L.S.D. was used to evaluate differences in birth sex ratio and adult sex ratio, and the significance of the test was established at $P < 0.05$.

RESULTS

Season and age at the beginning of harem formation: In this study, of the 15 young males living in the Misaki rang during the period from 1986 to 1997, 14 young males formed their new harem at the beginning of the breeding season (in late March). Only one case 6M was formed his new harems in the non-breeding season (in January). Furthermore, we found that 87% of these young males met their mares for a while before they become as one member in their new harems. At the beginning of the harem formation, these stallions formed their harem groups at the age ranged between 3.8 and 7.6 years with mean of 5.2 years (Table 1).

Factors affecting the age and process of the harem formation: During the study period, Misaki female horses outnumbered males as adults and the differences of the sex ratio at birth were not significant when compared to the adult sex ratio which more skewed towards females (Table 2). Furthermore, the highest number of theses females was wandering mares. The numbers of the wandering mares were 21–41 (mean $\pm 30.75 \pm 3.98$), while the stable mares were 3–12 (mean $\pm 8.75 \pm 3.98$) and the stallions were 12–22 (mean $\pm 14.25 \pm 3.01$). Therefore, the percentage of the

wandering mares was very high than mares which had a stable consort relations with the same stallions, not only in the breeding season but also in the non-breeding season. Moreover, the ratio between these wandering mares and stallions was 2:1 during the study period (Table 3). Lifetime stability were calculated individually for 29 mares which has become the nucleus of the new harems by the young stallions in this study. We found that 8, 5 and 16 wandering mares with lifetime stability was 0%, 1 to 59% and 60–79%, respectively, and no mares with a lifetime stability of over 80% were observed as wandering mares (Fig. 1).

Harem formation process: The young males started to acquired harems in two basic ways: (1) the young males picked up one or more wandering mares which they

separated from their mother or natal band, or 2) the young males associated with an established band and cooperate, in an apparent attempt to obtain mares by outright theft (Fig. 2). We observed 15 alterations in band structure which followed the two outlined patterns. The most common mechanism of band formation, in this study, for 13 out of the 15 alternations was for a young males to acquire one or more wandering mares. Commonly, the young mares left their original bands and became wandering females before joining their new partner when they became sexually mature. In this study, we showed 8 young sexually mature mares ranging in age from 2 to 3 years at the time their new bands were formed. Two of them became wandering after their mother died at early stage. Other 4 young mares separated with their mothers from the natal band and remained together as wandering mares. The last 2 young mares separated from their mothers around the birth of their siblings. On the other hand, the mares were all of these wandering mares were observed after separated from their mothers or natal bands either alone or associated from time to time with other harem groups, mixed sex groups and wandering female groups in the non-breeding season. In fact, some of these wandering mares met their new partner for a time during the aforementioned associations. Immediately before or early in the next breeding season, these mares separated from the associations and joined with prospective partner to form their new band. The last two alterations were made of horses which stole some or all of the unstable mares from other dominant stallions. The first observation was of two wandering mares separated from their natal band in the non-breeding season and that joined with another harem group. This group consisted of dominant stallion and two mares with their daughters and there has been a stable consort relationship between them in the previous breeding season. The associations between the wandering mares and the dominant stallion remained for up to 3 months and, after the first month, the young male M2

Table 1. Season, month and age at the beginning of the harem formation in Misaki feral horses

Male Name	Starting season and month of harem formation		Harem F. Age (Year)	Previous meeting ^{a)}
M12	breeding season	April	6.9	No
M57	breeding season	April	3.8	No
M74	breeding season	April	4.8	Yes
M8	breeding season	March	5.9	Yes
M10	breeding season	March	5.9	Yes
M7	breeding season	March	5.0	Yes
M6	Non-breeding season	January	7.6	Yes
M24	breeding season	April	5.0	Yes
M64	breeding season	April	3.8	Yes
M16	breeding season	April	4.9	Yes
M36	breeding season	April	4.9	Yes
M61	breeding season	April	4.7	Yes
M20	breeding season	April	5.9	Yes
M67	breeding season	April	4.9	Yes
M2	breeding season	April	5.0	Yes
Average			5.2	

a) The previous meeting between the stallion and his mares before starting his new harem with them.

Table 2. Sex ratio at birth (filly/colt) and adult sex ratio (mares^{a)}/stallion^{b)} from 1986 to 1997

Sex ratio	Year											
	86	87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97
Birth sex ratio	7:10	9:4	5:5	12:8	2:4	5:5	4:4	9:6	7:5	6:11	7:3	8:8
Adult sex ratio	46:12	46:12	43:13	42:13	38:13	40:12	35:13	37:13	36:14	33:16	37:18	41:22

a) Age 2 years and older; b) Age 4 years and older. There was no significant at the birth sex ratio ($P>0.05$), but a significant correlation was found in adult sex ratio ($P<0.05$).

Table 3. Percentage and numbers of the wandering mares^{a)} available per stallions^{b)} from 1986 to 1997

Sex ratio	Year											
	86	87	'88	'89	'90	'91	'92	'93	'94	'95	'96	'97
W.mares % ^{c)}	73	78	95	78	81	90	71	91	69	63	72	63
W.M/Stallion ^{d)}	34:12	36:12	41:13	33:13	31:13	36:12	25:13	34:13	25:14	21:16	27:18	26:22

a) Age 2 years and older; b) Age 4 years and older. c) The No. of wandering mares/No. of the total mares $\times 100$. d) No. of wandering mares/No. of stallion.

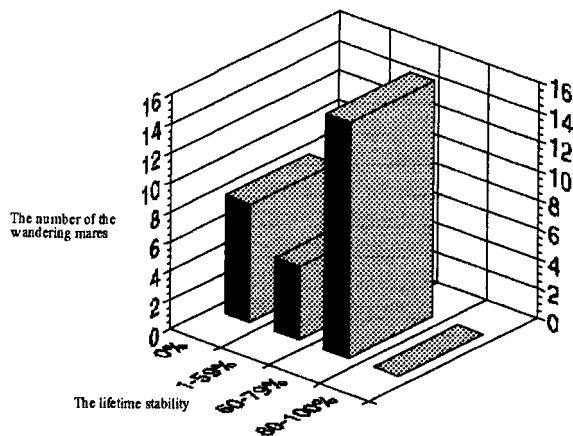


Fig. 1. Relationship between the numbers of wandering mares and its lifetime stability percent.

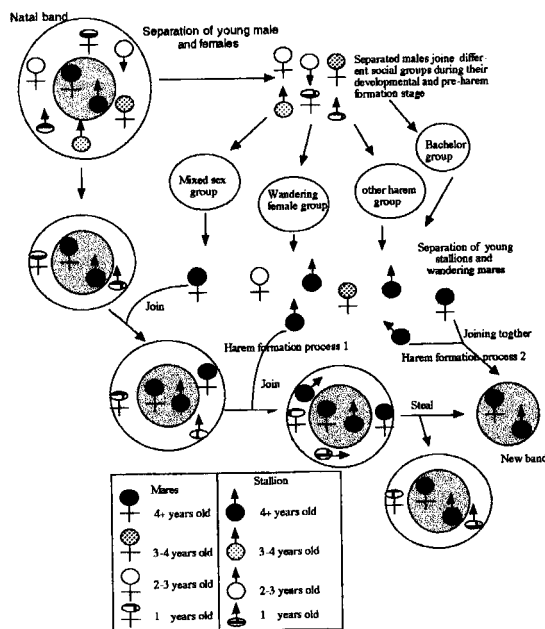


Fig. 2. Harem formation process exhibited by male Misaki feral horses.

joined once, remained for a week, and rejoined again two months later for two days. Afterwards, the young male M2 and wandering mares separated from the harem group to form a new breeding herd. The dominant stallions still remained with the members of the groups in a stable consort relationship which was as strong as that before the association of the two wandering mares in the previous non-breeding season. The second observation was also of two mares which separated from their harem groups and became wandering mares in the non-breeding season. At this time, one dominant stallion had lost his band when the mares

transferred to another harem and was alone. This stallion associated with the two wandering mares to form a new harem group for about 3 months. After this, and before the beginning of the breeding season, the young male M6 joined the group for 5 days and then formed its own harem with the mares. The dominant stallion was again alone for a while, and then formed another association with other wandering females to establish his own band.

DISCUSSION

The population of Misaki is highly female biased in term of sex ratio, the highest percentage of these females was the wandering mares, and also the ratio of the wandering mares available per stallion was more than 2.5:1 during the study period, explaining the observed average age of 5.2 years for all young males to obtain harems. Hence, acquiring a wandering mares might be better than fighting to obtain harems, because the opportunities for reproduction are still available, while the converse applied to old males [2].

The male Misaki horses are considered to be sexually mature at the age of 4 to 5 years [7]. However, the young males reach physiological maturity at the age of 5 to 6 years [18]. In Misaki area, young males in the bachelor groups bide their time, they learn some important stallion activity, such as play fighting, marking and mounting behavior through joining the bachelor groups during their developmental stage, which occurs between the attainment of sexual and physical maturity [14], and thereafter are physically ready to establish their own harem groups. In the New Forest, the ponies started forming their harems as early as February [26]. In Misaki this occurred as early as September is which the beginning of the non-breeding season [16]. In this season, wandering mares were frequently seen because of a decrease in grazing after September [5], severe winter weather [22], and instability of the herd in fall and winter [11]. Also, some adult mares change harem groups during the winter and spring [22, 25]. Therefore, the young males have a good experience to establish their own harems early through joining these wandering mares during the pre-harem formation stage [16]. In the present study, a young stallions formed his harems by two ways, the first one that the most of the young males appropriated their own harems by picking a wandering female [12, 23], and over 28% of these were young mares. These mares leave their natal band before or at sexual maturity and become wandering mares [3, 23, 24]. However, the other 72% were old mature wandering mares which had a different winter habitat from their harem stallions and lived alone or with their offspring in the winter home range [8]. Otherwise, the second way that stealing unstable mares from an established harem represents a second possible way that young Misaki feral stallions form their own harem. So, in two cases observed in this study, some mares separated from their harems and associated with the two stallions for a time before the beginning of the next

breeding season. In the meantime, young males attempted to drive the mares away from the resident male to begin their own harems [20]. Our observations indicated that a young male will trail the band at some distance, grazing close to them and wandering with them until he succeeds in separating these wandering mares, which become the nucleus of his new harem. Such mares are easier to steal because they do not become permanent members of a family, and therefore the dominant stallion apparently has a short attention span for them. In contrast, the established mares of the dominant stallion in the first case remained stable before and after separation of the wandering mares. This is because most stallions associate with one to two mares which are the nuclei of their harem during formation, and this bond is not only strong in the breeding season but also in the non-breeding season [9]. In some cases, once a breeding herd has become established it usually remains stable over many years [23]. However, the dominant stallion in the second case had lost his mares in the previous non-breeding season because he was young at that time, which is consistent with the conclusions of Stevens [25]. The stallion also lost his new wandering mares, which were stolen by a young male. However, he established his own harem by herding mares, which left other harem groups in the beginning of the breeding season.

During the formation of new harem groups either from wandering mares or steal mares from other harem groups in the previous winter. These 2 types of them had a lifetime stability below 79%, and all of them were seen to associate of their own accord transiently with some stallions before the formation of stable harem groups. During these associations they met with their prospective partner for a while and spontaneously formed a stable consort relation with this prospective partner when new harem groups are formed by the beginning of the new breeding season. Furthermore, Misaki horses are not controlled artificially and all mares are free to associate with stallions if they are not already dominated by another stallion [6], suggesting that the Misaki mares chose a partner by their own accord to form a new band, therefore, there is no antagonism among stallions over ownership of families, and no fighting. Thus, all of the stallions can live close together quite peacefully.

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