

FERAL HORSE SOCIAL STABILITY IN TORNQUIST PARK, ARGENTINA

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ABSTRACT: Feral horses (*Equus ferus caballus*) exhibit harem defense polygyny, and harem-bands are generally considered to be social units stable in time. We studied an unmanaged feral horse population with very high density and few predators in Tornquist Provincial Park, Argentina. Horses were observed on a fixed route 20 km long that covered the entire study area. The horses were individually identified based on coat color and characteristic marks on face and legs. Data on social group composition was taken monthly from 1995 to 1997, seasonally from 1998 to 2000, and monthly from 2000 to 2003. We calculated the percent of harem-bands formed and dissolved, the percent of adult female change and stallion tenure. Social stability was lower than previously reported, with 20% new harem-bands formed and 18% harem-bands dissolved annually. The average rate of change of adult females was 20% per year, and the stallion mean tenure of their harem-bands was four years. We found no significant relationship between social instability and population density or autumn-winter rainfall. In Tornquist Park the majority of harem-bands remained stable along each year during the eight years. However some harems were unstable, and some adult females changed harem-bands. At the same time many feral horses changed from their original harem-bands during the study period and this became evident only through long-term research.

RESUMEN: Estabilidad social de caballos cimarrones en el Parque Tornquist, Argentina. Los caballos cimarrones (*Equus ferus caballus*) presentan poliginia con defensa de harén y las tropas-harén son generalmente consideradas como unidades sociales estables en el tiempo. Estudiamos una población de caballos cimarrones no manejada, con muy alta densidad y pocos predadores en el Parque Provincial Ernesto Tornquist, Argentina. Los caballos fueron observados recorriendo un camino fijo de 20 km de longitud que cubría toda el área de estudio. Los caballos fueron identificados individualmente basados en el color del pelaje y las marcas características en cara y patas. Se tomaron datos sobre la composición de los grupos sociales mensualmente desde 1995 a 1997, estacionalmente de 1998 a 2000 y mensualmente de 2000 a 2003. Calculamos el porcentaje de tropas-harén formadas y disueltas, el porcentaje de hembras adultas que cambió de tropa-harén y la tenencia de los padrillos. La estabilidad social fue alta, con 82% de las tropas-harén estables anualmente. Por otra parte la estabilidad fue menor que la reportada por otros autores, con un 24% de nuevas tropas-harén formadas y 18% de tropas-harén disueltas anualmente. La tasa promedio de cambio de hembras adultas fue de 20% por año y la tenencia de las tropas-harén promedio de los padrillos fue de cuatro años. No hallamos una relación significativa entre inestabilidad social y densidad poblacional o lluvia en otoño-invierno. En el Parque Tornquist la mayoría de las tropas-harén fueron estables durante el año en los ocho años del período de estudio, sin embargo algunas fueron inestables y algunas hembras adultas cambiaron de tropa-harén. Al mismo tiempo muchos caballos

cimarrones cambiaron de su tropa-harén original a otra durante el período de estudio y esto sólo se hizo evidente a través de la investigación a largo plazo.

Key words. Equidae. *Equus ferus caballus*. Feral horse. Harem-band. Social stability.

Palabras clave. Caballo cimarrón. Equidae. *Equus ferus caballus*. Estabilidad social. Tropa-harén.

Feral horses (*Equus ferus caballus*), like plains zebra (*E. quagga*) and mountain zebra (*E. zebra*) present harem-defense polygyny, or Type I social organization as described by Klingel (1975). They form small social groups, the harem-bands, which consist of one adult male and some females and their offspring, which the stallion permanently defends. Males that dispersed from natal harem-bands formed bachelor bands.

Many authors consider feral horse harem-bands as social units that are very stable in time, with bonds between their members lasting some years or even for life (Tyler, 1972; Feist and McCullough, 1975; Welsh, 1975; Klingel, 1975, 1982; Kaseda, 1981; Rubenstein, 1981; Salter and Hudson, 1982; Keiper, 1986; Linklater et al., 2000). However, other authors have reported social instability, with moderate to high rates of adult female change-over between harem-bands (Berger, 1986; Franke-Stevens, 1990; Goodloe et al., 2000) and high harem-band formation and dissolution rates (Goodloe et al., 2000). Different explanations were proposed for the social instability observed: low resource availability at the end of winter at very high density (Franke-Stevens, 1990) and a combination of male biased adult sex ratio and high home range overlap (Goodloe et al., 2000).

There are very few long term studies of more than five years on the social organization of feral horses; notably, Berger (1986), Kaseda and Khalil (1996), Feh (1999), Goodloe et al. (2000), and Cameron et al. (2001). Our objective was to describe quantitatively in the long-term the social stability of the feral horses that inhabit Tornquist Park in Argentina, a population without management and at very high

density. We also try to explore if our results support any of the proposed hypothesis for social instability in feral horse populations.

Tornquist Provincial Park is located in south Buenos Aires province, Argentina (38° 00'-38° 07' S and 61° 52'-62° 03' W). This reserve covers 6707 ha of hilly grassland ranging between 450 and 1175 m a.s.l., with several permanent watercourses. The climate is temperate humid (Burgos, 1968) with a mean annual rainfall of 800 mm. The dominant vegetation is grassland steppe with species of the genera *Stipa*, *Piptochaetium*, *Festuca* and *Briza* (Cabrera, 1976; Frangi and Bottino, 1995).

A group of 10 horses of Argentine Creole breed were introduced to Tornquist Park in 1942, and they soon became feral. The feral horses inhabit an area of 2000 ha. The population has never been managed and potential predators are very scarce. The horses reached very high densities (22.5-35 horses/km²) between 1995 and 2003 (Scorolli, 2007). The latter are among the highest known densities reported for feral horses (Tyler, 1972; Welsh, 1975; Franke-Stevens, 1990; Duncan, 1992).

One observer (ALS) surveyed the population monthly from January 1995 to December 1997 and from September 2000 to February 2003, and seasonally from January 1998 to September 2000. Horses were followed on foot for two consecutive days along fixed routes of 20 km and observed by naked eye or with the aid of 10x50 binoculars. Members of all the harem-bands present in the study area were individually identified by coat colour and marks on the face and legs (Berger, 1986; Linklater et al., 2000). The horses were sexed by direct observation of external genitalia, and based on body size and tail length we assigned

them to four age classes: foal, yearling, 2 year-old, and adult (≥ 3 years).

To describe the social stability of the population we calculated the new harem-bands formed and dissolved as a percentage of the total number of harem-bands present per each year. We considered a harem-band dissolved when the stallion lost all his females and they became members of one or more different harem-bands. We also calculated the percentage of adult females (≥ 3 years old) that changed social group; females registered as foals in the first years of study dispersing from their natal harem-band were not included in the calculations. We analyzed the relationship between social instability and population density or autumn-winter rainfall by means of Spearman rank correlation. In November 2002 a feral horse mass mortality (Scorolli et al., 2006) precluded the estimation of the aforementioned parameters for the year 2002. We also estimated the mean stallion tenure in years during the study period, based on a minimum of one female of the original harem-band remaining with the stallion.

The total number of harem-bands present in the studied population increased steadily from 40 in 1995 to 66 in 2003. The annual percentage of harem-bands formed and dissolved and the percentage of adult female turn-over do not show a clear trend during the study period

(**Table 1**). New harem-bands represent on average 24% of the total harem-bands recorded each year, with a minimum of 10% in the year 1998 and a maximum of 32% in 2002. Number of harem-bands dissolved ranged from 10% to 25% yearly. Adult females that changed harem-bands averaged 20% of the total adult females present each year, with a range from 7% in 1999 to 30% in 2000.

We found no significant relationship between population density and adult female change ($r = 0.29$, $P = 0.53$), harem-band formation ($r = 0.15$, $P = 0.74$) nor harem-band dissolution rate ($r = 0.54$, $P = 0.21$). We found also no significant correlation between autumn-winter rainfall and the rates of harem-band formation ($r = 0.07$, $P = 0.88$) harem-band dissolution ($r = 0.06$, $P = 0.14$) or adult female change ($r = 0.189$, $P = 0.68$).

Stallion tenure averaged 4.4 ± 2.4 years for the harem-bands present in 1995 ($N = 40$), and 4.1 ± 2.3 years for the harem-bands formed in 1995-96 ($N = 14$). All stallions (20%) that reached the maximum tenure of eight years when our study finished had in average five adult females (range 2-8) and maintained only one or two of the females originally present in their harem-bands. The frequency distribution of tenure was clearly not unimodal, with a predominance of 1, 4, and 8 year tenure for the stallions of bands already present in 1995

Table 1

Percentage of harem-bands formed and dissolved and percentage of adult females that changed harem-band annually during the period 1995-2002. N= total number of harem-bands present in December each year.

Year	% bands formed	% bands dissolved	Total bands (N)	% adult female that change	Total adult female
1994	-	-	40	-	109
1995	30.0	12.5	50	18.3	130
1996	10.0	10.0	50	20.6	141
1997	25.9	20.0	54	19.3	160
1998	24.1	24.1	54	7.0	188
1999	24.1	24.1	54	30.1	192
2000	21.3	11.1	61	27.8	208
2001	32.3	24.6	66	18.6	210
Mean \pm SD	24.0 \pm 7.2	18.1 \pm 6.6	54	20.2 \pm 7.5	167

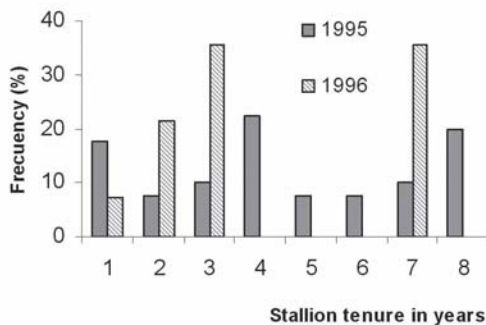


Fig. 1. Stallion tenure in harem-bands present in 1995 (N = 40) and newly formed bands in 1995-1996 (N = 14), during the period 1995-2002. N= number of harem-bands.

and tenure of 3 and 7 years for the stallions of bands formed in 1995-96 (**Fig. 1**).

We present for the first time data on feral horse social stability in Argentina, and this constitutes one of the few long-term (more than five years) studies of individually identified horses like those of Berger (1986), Duncan (1992), Kaseda and Khalil (1996), Feh (1999), Goodloe et al. (2000), and Cameron et al. (2001).

In Tornquist Park, social stability estimated as the percent of stable harem-bands on a year-round basis was very high (annual mean = 82%) in coincidence with the reported for feral horses by many authors (Keiper, 1986; Berger, 1986; Duncan, 1992; Cameron et al., 2001). On the other hand the mean percent harem-bands formed (24%) and dissolved (18%) annually is very much higher than the total percent registered during the complete study period of five or more years reported (Berger, 1986; Goodloe et al., 2000, Cameron et al., 2001) (10-24% new bands formed and 10-33% bands dissolved). The feral horse population in the Camargue, France, presents unusual social stability and Duncan (1992) registered no change in harem-bands during five years.

Our results showed that many adult female feral horses did not remain in the same social group during the study period. The mean percentage of adult females that changed harem-bands annually (20%) was higher than the

values reported by Duncan (1992), Feh (1999), Linklater et al. (2000), Rubenstein (1981), and Berger (1986) (2-12.5%), but lower than the highest known values reported by Franke-Stevens (1990) and Goodloe et al. (2000) (27-30%). We estimated that a minimum of 85% female horses in the Tornquist population disperse before reaching 3 years of age (Scorolli, 2007). In order to reduce bias we excluded from our analysis all females which were born after 1994 that apparently dispersed during the study period.

Stallion tenure within their harem-bands could be also an indicator of social stability. In the present study, mean tenure (four years) was higher than the values reported by Berger (1986) and Goodloe et al. (2000), 3.2 and 2.8 years respectively. Our results suggest that the distribution of stallion tenure is bimodal, with average stallions with 1-4 years, and more competitive stallions that reach 7 and 8 years. Kaseda and Khalil (1996) mentioned that stallions older than 10 years lost their females gradually and probably this may also occur for some oldest stallions at Tornquist, but we did not know their exact age to verify this.

The maximum tenure registered in Tornquist Park (eight years) coincided with the duration of the study period and could be an underestimate because surely many stallions formed their harem-bands before the project began. This value approached the maximum reported in populations without management (10 years) studied by Keiper (1976) on Assateague Island, USA, and Welsh (1975) on Sable Island, Canada. The percentage of stallions that achieved the highest tenure in Tornquist Park, 8 and 7 years (20-35%), was similar to that reported by Berger (1986, 33%) and Goodloe et al. (2000, 37%). Furthermore, Feh (1999) reported an exceptional maximum tenure of 18 years for the feral horses of Camargue, France, however this population was managed and the sex ratio of adults strongly biased toward females and therefore was not comparable with the population at Tornquist. Our results suggested that social stability in Tornquist Park population is very high on a year-round basis but at the same time many

members of the harem-bands changed from their original group in the long-term.

The social instability reported for feral horses by some authors was attributed to different factors and their relative importance remains unclear. Franke-Stevens (1990) suggested that food availability at the end of winter was the main cause of the harem-band instability she registered. We found no significant correlation between autumn-winter rainfall and the rates of harem-band formation, dissolution or adult female change. We assumed that in Tornquist Park grasslands rainfall could be considered as an adequate proxy of food resources for feral horses and this indicates that our results don't provide evidence in favour of Franke-Stevens hypothesis.

The adult sex ratio in the population has been proposed as a factor involved in social instability by Kaseda and Khalil (1996) but the present evidence is contradictory. Goodloe et al. (2000) attributed the high instability they observed to the uneven, strongly male-biased adult sex ratio (1.6:1) while other populations that showed social instability presented slightly female biased adult sex ratio (Berger, 1986 [0.76:1]; Franke-Stevens, 1990 [minimum 0.7:1]). In contrast, most feral horse populations that showed very high social stability presented strongly female-biased adult sex ratio (Duncan, 1992; Feh, 1999 [0.13-0.4:1]; Kaseda and Khalil, 1996 [0.13-3:1]) with the exception of one population that have unskewed adult sex ratio (0.9:1) (Linklater et al., 2000). Unfortunately we did not register the exact adult sex ratio, because of the difficulty in censusing unstable bachelor bands in hilly terrain, but a minimum adult sex ratio estimated from four years data in our study population was of 0.9:1 (Scorolli, 1999, 2007), suggesting that in our study population the hypothesis of Goodloe et al. (2000) is not valid.

The role of population density in the social stability remains unclear. Duncan (1992) and Feh (1999) reported very high social stability in a population that presents very high density (31 horses/km²) while Franke-Stevens (1990) registered the highest known instability in a short-term study in population with very high

density (35 horses/km²), but Goodloe et al. (2000) reported high instability in a population with low density (2.6 horses/km²). We found not support in our results of any significant relationship between social instability and the high population density estimated (22.5-35 horses/km²), but perhaps the range of density values observed was not wide enough to detect an effect.

The high stability of harem-bands year round observed is unusual among mammals and appears as characteristic of feral horses under very different demographic and environmental conditions (Klingel, 1982; Keiper, 1986). Our results suggest that life-long lasting bonds between harem-band members in feral horses as proposed by Klingel (1975, 1982) could be valid for some individuals in the Tornquist Park population, but many don't remain together in concordance with the results reported by Berger (1986).

Our results also suggested that feral horses in Tornquist Park present social stability. The majority of harem-bands were stable on a year round basis, some of them were unstable and some adult female change harem-bands. At the same time many members changed from their original harem-bands during the study period and this becomes evident only through long-term research.

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