POPULATION CHARACTERISTICS OF FERAL HORSES ON CUMBERLAND ISLAND, GEORGIA AND THEIR MANAGEMENT IMPLICATIONS

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Abstract: Control of feral horse populations (*Equus caballus*) on public lands is restricted to nonlethal methods. These methods can limit population growth; however, efficacy may vary among populations with differing demography and social structures. Characteristics of many western feral horse populations are well documented, but fewer data are available for Atlantic barrier island populations. Therefore, we monitored a population of feral horses on Cumberland Island, Georgia from 1986 to 1990. Population growth averaged 4.3% annually with a stable age structure. Mean size of bands with ≥1 stallion was 4.6 horses. The adult sex ratio for the population was 0.6 females:1.0 males. About 66% of mares foaled during a given year and no juvenile females foaled. Annual survival rates averaged 61.1% for female foals, 58.8% for male foals, and 92.4% for mares. Most bands contained a dominant or codominant stallion, mares and–or juvenile females, and foals. Most mares (62.5%) changed bands ≥1 time during our study. Bachelors represented 50.4% of stallions. These population characteristics differed from other feral horse populations. The small band size, large number of bachelors, high degree of band instability, and codominance of band stallions on Cumberland Island likely will limit the efficacy of some forms of nonlethal population control.

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Feral horses occur on 4 Atlantic coastal barrier islands managed by the U.S. Department of the Interior and are greatly valued by many of the islands' visitors (Kirkpatrick 1995). However, when feral horses become overabundant, their foraging and trampling can degrade natural communities (Turner 1988). Numerous management alternatives for minimizing the impact of feral horses on federally controlled public lands have been considered since the enactment of the Wild Free-Roaming Horse and Burro Act (Wagner et al. 1995). Even though this act was directed at the U.S. Forest Service and Bureau of Land Management, the National Park Service has adopted its guidelines. Horses are recognized by the National Park Service as a "desirable species" to be managed with indigenous wildlife to achieve an ecological balance (Kirkpatrick 1995).

The National Park Service manages much of Cumberland Island, Georgia for visitor-based outdoor recreation, including horse watching, while working to protect the island's flora and fauna. To achieve similar goals, managers on Assateague Island National Seashore, Maryland used fertility control to help limit the growth of their feral horse population. (Kirkpatrick 1995, Kirkpatrick et al. 1997). Although fertility control may be useful on Cumberland Island, specific demographics and structural characteristics of the population that are critical to the success of any management efforts (e.g., band size and stability, length of tenure for dominant stallions, mare productivity, and sexual maturity) may differ from those of other populations (Garrott et al. 1992). These data have been reported for several feral horse populations in the western United States; however, comparative data from coastal barrier island populations are more limited. Our study was designed to examine the social structure and demography of the feral horse population on Cumberland Island, Georgia, and to discuss the relevance of this information to population management.

MATERIALS AND METHODS

Cumberland Island is 28 km long, 0.8–4.8 km wide, and 95.5 km^2 in area (Hillestad et al. 1975). Cumberland Island National Seashore covers 80% of the island. A mosaic of plant

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communities exists on the island (Hillestad et al. 1975). Primary dunes, interdune meadows, and secondary dunes lie adjacent to the beach, and support sparse stands of grasses, forbs, and sedges. Dense shrub thickets, primarily of wax myrtle (*Myrica cerifera*), are scattered in the interdune meadows and on the rear dunes. Maritime forests with scattered pastures, cultivated lawns, pine plantations, and freshwater marshes cover most of the interior island. Grasses and shrubs occur at the elevated edges of the salt marsh, but the majority of the salt marsh is dominated by smooth cordgrass (*Spartina alterniflora*).

Free-roaming horses occurred on Cumberland Island in 1788 (letter to Edward Rutledge from Phineas Miller, on file at the Georgia Department of History and Archives, Miscellaneous File 470, ac 75-559), but we do not know if these horses contributed to the current gene pool or if the population is of more recent origin. Genetic variation measured in the island horses in 1986 was similar to mainland breeds, probably because of repeated introduction of domestic horses (Goodloe et al. 1991). Residents occasionally have captured and domesticated the island's feral horses, but no systematic population management has been implemented since Cumberland Island National Seashore was established in 1972.

A single researcher (RBG) surveyed different quadrants of the island on a daily basis from April to June 1986 to identify and age horses based on physical appearance, and to determine band and harem composition. We considered a band to be a group of various combinations of mares (adult females ≥3 years old) and juveniles (1–2 years old) with associated foals (<1 year old), and generally 1 or more stallions (adult males ≥3 years old). Some bands contained only a single mare with foals or juveniles. We considered a harem to be all band members, excluding the stallion(s). If a band had >1 stallion, then the dominant stallion was identified when he prevented the other band stallion(s) from breeding or foraging adjacent to harem females. Bands containing male offspring that had not yet dispersed were not considered to be multiple-stallion bands.

Horses were identified by color, face and body markings, and scar patterns. Additionally, 10 mares from 9 bands, primarily on the northern half of the island, were immobilized between November 1986 and February 1987 and fitted with radiotransmitter collars to facilitate band location and identification (Goodloe et al. 1991). During the 1986 survey, we assigned horses to 1 of 4 age classes based on body height, tail length, and muscle mass: (1) foals were identified at or shortly after birth, (2) 1-year-old horses were larger than foals and their tails did not extend beyond their hocks, (3) 2-year-old horses were larger and more muscular than 1-year-old horses, and (4) ≥3-year-old adult horses were the largest and most muscular. Horses born in 1986 or later were of known age for the entire study, thereby precluding concerns about potential aging bias (Garrott 1991*a*).

In addition, we observed the population during March to August 1987, March to September 1988, March to August 1989, May 1990, and September 1990 to document productivity, survival rates, and band stability during the breeding season. During these periods, we searched for horses in each quadrant of the island (divided on a north-south axis into 4 sections) ≥1 time per week. We conducted an annual census in August and–or September 1986–90 to locate all bands and bachelors and to estimate the population size, age structure, and sex ratio. If a known band or bachelor was not located, then data collected on the date closest to the census period were used to estimate population totals for the year.

We collected data on survival and band stability during 0.5 to 2-week periods in November and December 1986; January, February, and December 1987; January, February, October, and December 1988; and February, November, and December 1989. Annual survival rates of adult and juvenile females were estimated by dividing the total number of females within each age class during the previous year (denominator) into the number of those that survived until the following year (numerator). In the absence of a carcass, we assumed that a female died if she had not been seen within a 1-year period. Mortality of adult and juvenile males was less easily documented because their movements and associations with other horses were less predictable. Therefore, we assumed male survival rates were similar to those calculated for females. We considered a mare to have changed bands if she was found with a different stallion or was observed for several days without a stallion. We assumed juveniles dispersed if they were located without their dams (or their

Table 1. Size and social strucure of feral horse populations on Cumberland Island, Georgia, 1986 to 1990.

Year	Minimum population	Bands	Band stallions	Bachelors <3 years old	Bachelors >3 years old	Harem members
1986	186	31	35	3	47	101
1987	194	31	33	4	45	112
1988	200	36	40	9[a]	37	114
1989	206	38	42	5	38	121
1990	220	41	42	5	36	137

[a] Includes a 2-year-old juvenile female that associated with multiple groups of bachelors in 1988.

dams' last band, if she died). Dates of mare movement among bands, juvenile dispersal, or the end of a dominant stallion's tenure were estimated as the median date they were last seen with the band.

Throughout the foaling season, we made direct counts of live foals and searches for carcasses when foal mortality was suspected. We assumed that a mare's foal died before being counted if the mare was not seen with a foal, but she had a full udder or appeared pregnant during the foaling season, or if an unidentified, dead foal was found within her range. When mares without foals could not be located on more than 3 occasions during the foaling season, they were excluded from annual reproduction calculations because foal mortality could not be documented. Mares that died during the study were included in these calculations if a necropsy was conducted to confirm pregnancy, or if they had been visibly pregnant before death. Foals that died in utero were not included in calculations of foal mortality, but were included in annual reproduction calculations. Parturition date was known for most foals. When not known, parturition date of a surviving foal was estimated as the median date from when the mare was last seen without, and first seen with, a foal. Parturition dates for dead foals were determined based on condition and size of a foal's carcass. If a carcass was not recovered, parturition dates were estimated based on visible evidence of pregnancy (enlarged abdomen and distended udder). Foal survival was monitored from parturition until 1 month postpartum, and at the annual census thereafter.

During 1990, we counted foals as described above, but also estimated the pregnancy status of mares by analysis for fecal and urinary steroid metabolites (Kirkpatrick et al. 1988, 1990). For these analyses, we collected fecal and urine samples immediately after deposition by mares during July to December 1989.

We used t-tests to compare survival of different age classes among social groups or between sex and age groups, foal production by mares, rate of juvenile dispersal from bands, and age of juvenile dispersal. For sample sizes, we used the concept of a mare-year for repeated annual observations on a single mare among years. Significance was accepted at $\alpha < 0.05$.

RESULTS

Population Size, Productivity, and Survival Rates

During the 5 years of our study, the population increased from a minimum of 186 to 220 horses (Table 1). Estimated annual growth of the population averaged 4.3% among years (range 3.0–6.8%).

Foals were born on Cumberland Island during February to September, but most births (77 of 100 foals with a known parturition date) occurred during April to June. We estimated that 178 foals were produced from 1986 to 1990, with no twins (Table 2). Each year, we observed 51 to 62 mares (Table 2), of which an average of 61.0 + 1.8% (SE) foaled in a given year. Of these, we observed 40 frequently enough to determine if they foaled annually among consecutive years. Seven of the 40 (17.5%) produced

Table 2. Annual production by feral mares (≥3 years old) with known foaling histories on Cumberland Island, Georgia, from 1986 to 1990.

Observations	1986	1987	1988	1989	1990
Mares	51	59	57	62	62
Mares that foaled	28	36	37	37	40
Foals surviving to annual census	24	25	23[a]	23	28
Foals that died before annual census	4	7	7[a]	8	12
Mares visibly pregnant but without a foal	0	2	7	3	0
Foals that died in utero	0	2	0	3	0

[a] Includes 1 sick and 1 healthy foal that were captured several days after birth and released in late 1989.

Table 3. Composition of the feral horse population, excluding bachelors, on Cumberland Island, Georgia, at the annual census.

Year	Foal		1 year old		2 year old		3 year old		4 year old		>4 year old	
	M	F	M	F	M	F	M	F	M	F	M	F
1986	13[a]	10	6	8	4	4	—[b]	—	—	—	35	56
1987	9	16	12	10	0	8	1	3	—	—	33	53
1988[c]	13	7[d]	8	14	4	7[e]	1	7	1	3	40	47
1989	11	12	11	7[d]	3	13	2	8[e]	1	7	42	46
1990	10	18	9	11	9	9[d]	0	12	2	8	42	49

[a] The 1986 total does not include 1 male foal that was associated with bachelors (see Table 2).
[b] Horses that were 3 or 4 years old in 1986 could not be aged accurately; therefore, they were listed under the >4-year-old column.
[c] Two foals were of unknown sex.
[d] The 1990 total includes 2 females born during 1988 that were maintained in captivity until late 1989 (see Table 2).
[e] The 1989 total includes the female that, as a 2-year-old in 1988, was associated with multiple bachelors (see Table 1).

a foal or fetus each of the 5 years; 6 (15.0%) foaled during 4 years, 16 (40.0%) foaled during 3 years, 8 (20.0%) foaled during 2 years, 1 (2.5%) foaled 1 year, and 2 (5.0%) did not foal. Foal production by mares that changed bands from 1 year to the next (44.2% foaled, $n = 77$ mare-years) was lower ($P < 0.001$) than that of mares in stable bands (70.8% foaled, $n = 154$ mare-years). None of the 2-year-old juvenile females ($n = 41$) and only 5 (16.6%, $n = 30$) of the 3-year-old mares foaled or tested pregnant based on steroid fecal analysis. Only 2 of the foals produced by 3-year-old mares survived until the next annual census; 3 of them died in utero or shortly after birth.

Recruitment of juveniles into the population was limited by low survival of foals. Only 71 of 105 foals (67.6%) born during 1987 to 1989 (the 3 years of most intensive observations) survived from birth until the annual census in August–September. Thirty-three of 34 foal deaths occurred during the first month postpartum. Foals born before 1 June were more likely ($P < 0.001$) to survive (81.3% survived, $n = 64$) the critical period 1 month after birth than foals born after 1 June (47.2% survived, $n = 36$). Foal sex ratios throughout the study averaged 1.0 females:0.90 males ($n = 135$, range = 1.0 females:0.5–1.4 males); sex-biased foal mortality was not evident in the 14 dead foals examined. Postpartum foal survival did not differ between mares that remained with their existing bands or moved to a new band ($P = 0.543$). Foal survival was lower ($P = 0.005$) in the southern (61.0%, $n = 82$) than northern half (80.2%, $n = 91$) of the island. Causes of mortality were unknown. During 1987 to 1989, there was no difference ($P = 0.811$) between survival rates of female (61.1% surviving; $n = 54$) and male (58.8% surviving; $n = 51$) foals to 1 year of age.

Annual survival rates of mares averaged 92.3 ± 1.1% ($n = 263$ mare-years; calculated at time of annual census) during 1986 to 1990.

Band Social Structure, Stability, and Dispersal Behavior

Most bands (85.9%) that we counted during the annual censuses ($n = 177$, Table 1) were composed of mares, juveniles, foals, and a single, dominant stallion (Table 3). However, 19 bands (10.7%) contained ≥2 stallions that shared dominance and 6 bands (3.4%) contained only mares and their offspring. Of the 171 bands with ≥1 stallion and mare, the average band size was 4.6 ± 0.1 horses (range = 2–10 horses) with an average of 1.8 ± 0.1 mares. The average adult sex ratio within bands was 1.6 females:1.0 males; within the population, it was 0.8 females:1.0 males. Bachelor stallions averaged 51.4% of the adult male population among years (range = 46.1–57.7%).

Observed tenure for stallion dominance was not lengthy. Only 13 of 35 (37.1%) stallions that were dominant or codominant during the 1986 census maintained ≥1 harem members through September 1990. Average tenure for these 35 stallions was 2.8 ± 0.3 years.

Thirty-three new bands (excluding 6 all-female bands) formed between April 1986 and September 1990 when ≥1 bachelors acquired juvenile females ($n = 9$), young (3–4-year-old) mares ($n = 5$), or a mixture of mares, juvenile females, and foals ($n = 19$). A 34th new band formed in 1987 when a 3-year-old band stallion became dominant over part of his harem when its dominant stallion died. By September 1990, 11 of these 34 bands had disbanded.

Forty mares alive in 1986 survived through September 1990. Of these, 15 (37.5%) remained with their original dominant stallion(s) and 25 (62.5%) changed bands. Of these 25 mares, 10 changed bands at least once, 5 changed bands at least twice, 3 changed bands 3 times, and 7 changed bands ≥4 times. From 1 breeding season to the next, 29.6% of mares (n = 220 mare-years) and 34.5% of females ≥2 years old (n = 249 mare-years) associated with ≥2 bands. Two-year-old females were more likely (72.4%, n = 29, $P < 0.001$) to change bands during the year than mares (29.6%, n = 220 mare-years). There was no difference (P = 0.099) in dispersal by 3-year-old mares (47.1%, n = 17 mare-years) versus mares >3 years of age (28.1%, n = 203 mare-years). Changes in band structure due to dispersal by mares occurred throughout the year, but were most common during April.

We did not observe territorial behaviors among horse bands on Cumberland Island. Most bands, even on the narrow southern tip of the island, occupied overlapping home ranges. Stallions defended only those areas immediately adjacent to their harems. We observed 2 occurrences of forced copulation.

Juvenile females dispersed from their dams or bands at 22.3 ± 1.9 months of age (range = 11.5–35.0 months, n = 17). No differences (P = 0.418) were noted in the dispersal ages of those that left their natal bands (23.6 ± 2.4 months, n = 10) compared to those that changed bands with their dams before dispersal (20.4 ± 3.0 months, n = 7). Juvenile males (P = 0.204) dispersed from their dams at 25.2 ± 1.2 months of age (range = 16.8–34.3 months, n = 16). The percent of the population composed of juveniles (Table 3) remained relatively stable from 1988 to 1990 (annual $\bar{x}$ = 31.5 ± 0.7%, n = 626).

DISCUSSION

Population Size, Productivity, and Survival Rates

Dense vegetation and restricted access to parts of the island limited our population surveys. We believe that we counted most of the island's feral horses, however, 4 unidentified juvenile females were discovered on the northern half of the island from 1988 to 1990. Therefore, we stress that our estimates represent minimum population size.

Earlier estimates, based on ground and aerial surveys conducted over relatively short periods, reported a 7.0% increase in the Cumberland Island horse population (144 to 154 horses) from July 1981 to March 1983 (Ambrose et al. 1983, Lenarz 1983). A survey in May 1985 estimated that there were 181 horses or 18% more than in 1983 (Finley 1985). Direct comparisons of population estimates should not be made between the previous studies and ours because of differences in the timing of censuses relative to foaling.

Our observations from 1986 to 1990, using standardized census methodology after annual recruitment, documented slow growth ($\bar{x}$ annual growth of 4.3%) of Cumberland Island's feral horse population, likely because of density-dependent responses resulting from limited forage availability (Turner 1988). During the period from our last census in September 1990 until the next census in October 1991, the population may have declined by about 18% (40 horses) because of an outbreak of eastern equine encephalitis (R. B. Goodloe, U.S. Fish and Wildlife Service, unpublished data). Subsequent spring surveys conducted during 1994 to 1997 by National Park Service personnel suggest that the population, before annual recruitment, has fluctuated around a median of 214 horses (J. Bjork, National Park Service, personal communication).

Annual population growth of Cumberland Island horses from 1986 to 1990 was lower than reported for feral horses on Assateague Island National Seashore, Maryland, where the population grew from 42 horses in 1975 to 80 in 1982 (90% increase; Keiper and Houpt 1984). Wood et al. (1987) reported an average annual growth of 15.5% for the horse population on Shackleford Banks, North Carolina. Annual growth rates on Cumberland Island also were lower than reported for western feral horse populations (range from 10 to 20% annual growth; Wolfe 1986).

The large growth rates for some western horse populations (e.g., up to 20% annually) occur because of high annual survival and fecundity (Eberhardt et al. 1982). Annual survival rates of mares on Cumberland Island were high (92.6%) and similar to those reported for western mares of 3–13 years of age (>92%; Garrott 1991*b*); however, fecundity rates for our mares were lower than for western mares. Annual foaling rates by Cumberland Island mares were similar to the average for mares in an unmanaged population on Assateague Island (57.1%; Keiper and Houpt 1984), but higher than reported for the same unmanaged population during 1989 (32.5%; Kirkpatrick and Turner 1991). Comparative foaling rates from an intensively managed population on Assateague Island ranged from 62.5 to 74.4% (Keiper and Houpt 1984, Kirkpatrick and Turner 1991). In the western United States, 43.2–83.0% of mares foaled annually (Kirkpatrick and Turner 1986). Berger (1983) reported reduced mare productivity in unstable bands. It is possible that the low fidelity of mares to bands on Cumberland Island contributed to their low foaling rates.

In most populations, mares produce their first foals at 3 years of age (Kirkpatrick and Turner 1986). However, Berger (1986) and Wolfe et al. (1989) reported that from 12 to 36% of 2-year-old mares might foal. Our study and that of Keiper and Houpt (1984) suggest that 2-year-old females on coastal islands are reproductively inactive. Timing of foaling on Cumberland Island was similar to the distribution of foaling dates on Assateague Island (Keiper and Houpt 1984). Peaks in foaling mirrored peaks in mare movement among bands, possibly an artifact of postpartum estrus that occurs 5 to 12 days after foaling (Ginther 1979).

Foal survival rates on Cumberland Island (58.8–61.1%) were lower than western feral horse populations (>80%), as reported in a review by Garrott et al. (1992). Low survival rates for foals born after 1 June likely were associated with increased ambient temperatures, potentially greater parasitism by insects, and reduced forage quality. We speculate that the significantly lower postpartum survival of foals we observed on the southern versus northern half of Cumberland Island may have been related to a greater abundance of pasture in the southern part of the island and the occurrence of fescue (*Festuca* sp.; Hillestad et al. 1975). Fescue toxicosis can cause domestic foal mortality (Cross et al. 1995), and may have caused the lower foal survival we observed. This possibility should be examined in future research.

Band Social Structure, Stability, and Dispersal Behavior

Composition of horse bands on Cumberland Island was similar to that on other coastal islands and throughout the western United States (Kirkpatrick and Turner 1986). However, Cumberland Island horse bands were smaller than those on Assateague Island ($\bar{x}$ = 8.1 horses; Keiper 1984) and Shackleford Banks ($\bar{x}$ = 12.3 horses; Rubenstein 1981). The codominance we observed among band stallions also was reported for feral ponies on Assateague Island (Keiper 1986). Eagle et al. (1993) reported that codominant stallions alternated dominance every 2–3 months and that this behavior was reflective of unstable bands. Band instability (mare infidelity, juvenile dispersal, etc.) was a common occurrence on Cumberland Island, and may have contributed to codominance. Furthermore, behavior of mares within bands did not suggest permanent bonds with other harem members, as indicated in the review by Slade and Godfrey (1982).

Berger (1986) reported a negative correlation between average band size and the number of males in the population. This scenario may apply to Cumberland Island, particularly on the southern end of the island. We observed more stallions, including bachelors, per mare than did researchers in western feral horse populations (1.0 mares:1.0 stallions, Feist and McCullough 1975; 1.0 mares:0.8 stallions, Berger 1986; and 1.0 mares:0.6 stallions, Garrott and Taylor 1990). Garrott (1991*b*) indicated that adult sex ratios of western populations were heavily skewed towards females, but this trend reversed for horses >10 years old.

Horse bands on Cumberland Island were socially unstable. Our estimates of band stability and stallion dominance were limited to observations conducted from March to September; additional changes within and among bands may have occurred from October to February. Bands were less stable than those in the western United States (Feist and McCullough 1975, Berger 1977), although the process whereby new bands formed was similar to that observed in Wyoming (Miller 1979). The band instability we observed contrasted with that reported by Rubenstein (1981) for feral horses on Shackleford Banks, North Carolina, where stallions defended well-defined territories on flat and narrow salt marshes. The tenure of dominant stallions on Cumberland Island was slightly shorter than that reported for stallions in Nevada (Berger 1983). The lack of territorial behavior, high degree of home range overlap, large number of bachelors, and presence of codominant stallions within bands may have contributed to the unstable social structure we observed.

Most dispersal from bands on Cumberland Island occurred when horses were about 2 years old. Our estimates of dispersal age were slightly younger than those reported by Berger and Cunningham (1987).

MANAGEMENT IMPLICATIONS

Turner (1988) recommended that the Cumberland Island horse population be reduced and maintained at 49–73 horses to allow recovery of the island's salt marshes. Lethal control programs to reduce feral horse populations, while effective, are seldom publicly acceptable (Garrott et al. 1992). Therefore, population control efforts must focus on various nonlethal techniques, most notably, horse adoption or fertility control. Horse adoption programs can be quite expensive, and concerns exist about the long-term care of adopted horses (White 1986, Garrott et al. 1992). Additionally, mares may become more productive if foals are removed before weaning (Kirkpatrick and Turner 1991).

The National Park Service may want to consider a combination of horse adoption and fertility control to achieve a more satisfactory long-term management solution for Cumberland Island. The degree of band instability, large number of bachelors, and codominance of some band stallions that we observed limits the efficacy of male-based contraception (Eagle et al. 1993). Female-based contraception may reduce the intervals between horse removals (Garrott et al. 1992). Deterministic models have been used to identify the optimal combination of management techniques for feral horse populations (Garrott et al. 1992). Our data can be used in these models to predict feral horse dynamics on Cumberland Island in response to various management programs.

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