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CHEMICAL RESTRAINT OF WILD HORSES: EFFECTS ON REPRODUCTION AND SOCIAL STRUCTURE

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ABSTRACT: Twenty-three (9 male, 14 female) wild horses (*Equus caballus*) in the Great Basin Desert were immobilized by ground techniques with succinylcholine chloride during 1,950 person-hr. Induction ($\bar{x}$ = 2.09 ± 0.59 min) and recovery ($\bar{x}$ = 12.4 ± 5.0 min) were rapid and most animals were returned in less than 10 min to original bands. Dosages ranged from 0.66–0.77 mg/kg body weight and neither abortions nor band changes in group membership resulted. However, a few concerted efforts up to 24 hr were needed to return some animals to original bands and three non-drug related mortalities occurred. The responses of bands to darted members and the overall influence of the operation on reproduction, movements, and social structure are presented.

INTRODUCTION

The existence of feral animals on public lands has resulted in lively controversies during the past 20 yr. In the Great Basin Desert of North America, an estimated 40,000 horses and burros (*E. asinus*) roam freely (BLM, 1982). Understanding the demography of wild horses has been hampered by a lack of data on factors influencing reproduction and age-specific fecundity under natural conditions.

If the ages of animals with known reproductive histories were available, it would be possible to assess the contribution of various age cohorts to the breeding population. We have been studying a population of wild horses with identified individuals for the past 4.5 yr and undertook a large-scale immobilization operation to determine the age structure of the population. This paper reports, to our knowledge, the results of the only ground-immobilization of wild horses. Specifically, we describe: 1) reasons for the costly, but necessary, groundwork; 2) techniques used in chemical restraint; 3) behavioral and reproductive responses of horses; and 4) impacts of the operation on social structure.

Abundant information concerning the effectiveness of various agents of restraint upon equids is available (Stowe et al., 1958; Fowler, 1978; Dodman, 1980; Lemaire and Blais, 1982) but only recently have equids been immobilized in the field (Klingel, 1967). In feral horses, aerial darting programs have employed a variety of drugs (Borchard, 1980) and involve chasing bands prior to firing projectiles and, subsequently, landing helicopters near immobilized animals (Seal et al., 1983). Although there is little danger to the restrained animal, its band members may be frightened away from the site and difficulties can arise in returning the darted animal to its original band.

In wild horses, the social environment of an individual plays a major role in its ecology and reproduction. Horses live in bands that consist of an adult male, the stallion, and his harem (females and young) (Keiper, 1976; Berger, 1977; Miller and Denniston, 1979). Past studies have not concentrated on the relationships between band stability and female reproductive success. In species such as langurs (*Presbytis entellus*) and lions (*Panthera leo*), which are characterized by social systems broadly similar to horses and some other equids (Klingel, 1975), reproduction is impaired in groups with frequent membership changes. In these species, males have been implicated as the cause since they occasionally kill unrelated offspring and re-inseminate females once they return to estrus (Bertram, 1975; Hrdy, 1977).

In the wild horses we have studied, females that change bands experience lower reproductive rates than females that remain in stable bands. The effects of age and stability in this relationship can be separated to some extent by comparing young (4 yr or less) females with those 5 yr and older in both stable and unstable (e.g., stallion or mare changes) bands. Regardless of age, females from unstable bands (young = 25% foal production, older = 63%) had significantly lower reproductive success than those from stable bands (young = 64%, old =

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89%, arcsin transformation to test the equality of percentages; $z = 2.44$, $P < 0.01$, $n = 41$ and $z = 2.02$, $P < 0.05$, $n = 71$, respectively). Although other factors are also involved in reproductive suppression (Berger, 1983), these data illustrate that factors associated with band instability or male takeovers of harems mediate decreased female fecundity and that young females are more seriously affected.

Since changes in the social environment influence reproduction, we decided to immobilize animals using ground procedures. We believed that stresses on individual animals and disruption of the social structure could be minimized by stealth rather than by using the more traditional aerial approaches.

METHODS AND MATERIALS

Study site and animals

Wild horses have been studied since 1979 in the Granite Range, a small fault-blocked mountain, in the Great Basin Desert of northwestern Nevada. All 130 animals in the population have been identified by natural color patterns. At the inception of the study, ages of young animals were estimated based on body size and tail length and maternal affiliation. Birth dates were known for foals born after early 1979. Furthermore, the bodies and skulls of 12 known, mature, live horses that disappeared after the study began were discovered. Their ages were estimated by tooth wear and eruption patterns (Ensminger, 1969; AAEP, 1971; Wade, 1977).

The immobilization operation continued sporadically from March until December 1982. Materials were transported to a remote base camp once by helicopter and horseback and over 20 times by backpack trips.

On three occasions early in the project the only deaths occurred due to equipment-use related problems. These basically stemmed from difficulty in estimating accurately distances from which to dart in extremely varied terrain and employing .22 cartridges of the appropriate load.

Drugs and body weight determinations

Succinylcholine chloride (SCC) (Sucostrin; Squibb & Son, New York 10222, USA), a potent paralyzer of voluntary muscle, was used because of its rapid action. A 10% solution was used so that small volumes (3–4 ml) could be injected in appropriate-sized projectile syringes. Approximately 0.65 mg/kg (30–35 mg per 100 lb) of the drug was administered intramuscularly. The drug was carried in 4–5 cc Palmer Cap-Chur Syringes, fitted with either cloth or Simmins tail pieces. Barbed needles were 1¼″ in length and darts were projected by extra long range Palmer rifles using a variety of percussion caps (.22 blank charges).

Body weights were estimated visually and determined subsequently by: $W = G^2L/k$, where W = body weight, G = chest girth, L = body length, and k = the constant, 228.1 (Milner and Hewitt, 1969). In our weight determinations, we averaged 94.7 (±5.7)% accuracy in matching prior estimations with weights calculated by the above methods.

Procedures

Several methods were employed to approach within 50 m of horses, the distance necessary for producing accurate shots. Because some animals were habituated to our presence, they were more easily approached and darted. This easy method was short-lived. Consequently, three alternative tactics were used. First, animals were very gradually (over several hours) moved by assistants toward hidden rifleholders. Second, markspersons were stationed at waterholes or in blinds constructed along travel routes. Third, stealth was used to surprise animals. None of these methods was more reliable than the next. Approximately 1,950 person-hr were spent locating and stalking horses.

The statistical tests used included standard nonparametric techniques, correlation, and the arcsin transformation for testing the equality of two percentages (Sokal and Rohlf, 1969). Specific tests are identified parenthetically.

RESULTS

Effects of dosage on induction and recovery times

The latency of response between shooting horses and the period of immobilization was short ($\bar{x} = 2.09 \pm 0.59$ min) and recovery was also rapid ($\bar{x} = 12.4 \pm 5.0$ min; range, 6–24). Three of the animals that exceeded the median recovery period (11 min) displayed signs of post-immobilization stress; they would either stumble, fall, or lie down for an additional 20–70 min.

We were unable to detect relationships between our accuracy in weight estimation (and hence dosage administered) and: 1) recovery ($r = 0.13$; NS) or 2) induction ($r = -0.12$; NS) times. Presumably, the lack of correlation was due to the small amount of variation in percent accuracy in our estimates; thus, the data were not very stratified. However, the weights of the three animals that rested for prolonged periods of time after immobilization were overestimated by an average of 14.3%. This differed significantly (Wilcoxon matched-pairs test; $t = 11.09$; $P < 0.001$) from animals whose weights were more accurately estimated (mean deviation was 3.8% versus 14.3%) and who did not rest after recovery. Although no mortality resulted from overdosages of drugs, the above data suggest that animals whose weights were overestimated by more than 10% showed lingering drug-related effects. These lasted no longer than 2–3 hr and in none of these cases, was stimulation of respiration needed.

Despite estimating weights with a high degree of precision, we cannot explain why some animals failed to show drug-related responses when shot. On 11 occasions darted animals were not immobilized. Of these, two internal charges in darts did not fire, two when dart penetration did not occur, two when animals never became ataxic, and in the five remaining cases animals were ataxic but not immobile.

Effects on behavior, movements, and reproduction

To minimize stress on horses we generally remained motionless once darts were fired until after drugs had taken effect. Although darted animals averaged about 230 (±383) m in subsequent movements, variation was great (range, approximately 15–1,700 m). After animals became recumbent, they were approached rapidly which resulted in flight of band members ($\bar{x}$ distance = 670 ± 586 m; range, 75 to 2,000 m). Consequently, we attended to two problems, collecting information from the immobilized animal and at the same time remaining cognizant of the location of its band.

The median return time was only 10 min but in three cases it took 16, 20, and 24 hr to return immobilized animals to their bands. In each of these, problems stemmed from: 1) poor visibility between a darted animal and its band; or 2) interference by wandering, vigilant bachelor males.

Responses of group members to immobilized band mates varied. When bands were not immediately disturbed by us and females were darted, stallions and offspring (foals or yearlings) of the immobilized females were more likely to investigate by sniffing or pawing darted animals than were other band members ($\chi^2 = 16.84$; $P < 0.001$). Stallions responded 58% (7 of 12) and offspring 57% (8 of 14) of the time to darted individuals. In contrast, haremic females and young merely stared at immobilized stallions or they fled. Only once did a yearling (female) and an adult female investigate an immobilized male.

Females were darted at stages of pregnancy that varied from approximately 1 to 9.5 mo. State of pregnancy was determined by known copulation and birth dates (Berger, 1983). We suspect the immobilization had no effect on a female's later reproduction because: 1) no immobilized females subsequently aborted, including three females in their last trimester of pregnancy; and 2) females were returned to their original bands.

DISCUSSION

A major concern in any immobilization is the enhanced possibility of mortality. In wild horses an additional problem stems from indirect (fetal) mortality because female fecundity is related to band stability. Although the time expended in the immobilization may, at first, appear great, it was not considered excessive for the following reasons. 1) Sizes and weights of animals could be estimated accurately—the drug dosages resulted in no mortality. 2) The home ranges and travel routes of all bands became known, thus enabling the return of immobilized animals directly to bands or areas frequented by other band members. 3) Animals varying in reproductive condition and with known histories (e.g., fecundity, behavioral categories, home range types, etc.) could be selected non-randomly for immobilization. 4) Animals could be darted with a minimum of stress and disruption of the social structure.

Concern has justifiably increased (NRC, 1982) over the use of SCC as an immobilization agent. We found it to be an effective and rapidly working drug with little variation in induction and recovery periods. For these reasons it was well suited for our purposes. Nevertheless, there were problems. When induction failed after animals were darted, it was unclear whether this resulted from individual variation among animals, or drug or mechanical failure. SCC is known to be unstable (Fowler, 1978). Perhaps its storage in aluminum projectile syringes for 24–36 hr periods under diverse and often subfreezing conditions produced interactions that retarded its potency. Alternately, the problem(s) may not have been strictly drug-related since five of the seven non-induced animals were in better physical condition than the ones who were knocked down.

Two noteworthy behavioral responses occurred in Granite Range horses. First, one band vacated a portion of its home range for 5 days after restraint efforts were concentrated in that area. Subsequently, immobilization attempts were never centered in the same area longer than a few hours and horses did not forego use of such areas. Second, toward the end of the operation, some bachelor males appeared to key in on our immobilization efforts. They were consistently in proximity to us and interfered with our attempts to return females to their original bands. During such episodes, the males chased, harassed, and tried to acquire the females. This was particularly true on several occasions when stallions were immobilized. Although we overcame these persistent males, it is possible that their appearance at our arrival was more than fortuitous. Perhaps they acted opportunistically to increase their mating chances after individuals were immobilized.

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NOTE ADDED IN PROOF

We feel it is important to explain our use of a neuromuscular blocking agent when both the Declaration of Helsinki (1977, Am. J. Physiol. 233: 174-F) and a National Research Council report (1982, op. cit.) consider the use of such drugs inadvisable. At the time our research was conducted the original permission to use etorphine, the drug we advocated, was revoked by the U.S. Department of Interior (Bureau of Land Management [BLM]). Instead, based on findings funded by the Bureau (Borchard, 1980, op. cit.), agents of the BLM permitted our use of *only* succinylcholine chloride.