Reviewed

Special Issue:
The Feral Horse

FERTILITY CONTROL AS A MANAGEMENT TOOL FOR FERAL HORSE POPULATIONS

John W. Turner, Jr., PhD[1] and Jay F. Kirkpatrick, PhD[2]

ABSTRACT

Technology for the humane regulation of feral horse populations is currently inadequate. The application of fertility control technology to feral horses may yield improved management capabilities. The present paper addresses the possibilities for fertility control in feral horses within the framework of characteristics of the ideal contraceptive. The pros and cons of various methodologies are given, with resultant selection of the preferred ones. A brief description of completed and current studies of feral horse fertility control is presented, with constructive critical analysis of each technique for males and females. Finally, projections are made for relative cost effectiveness of the most studied fertility control method in comparison with Adopt-A-Horse.

It is the purpose of this presentation to describe recent and current research toward the development of chemical fertility control technology for feral horses and to examine the potential of such technology for management of feral horse populations. Let us begin with a brief historical vignette.

In 1973, we became interested in the wild horse issue and alleged overpopulations of these animals.[4] With our backgrounds in reproduction and endocrinology, it was not surprising that we would think of "birth control" to address the issue. Of course, to pursue this idea required an understanding of the basic reproductive physiology and behavior of feral horses. The core of this has been addressed earlier in the symposium and it represents data collected since 1974. Beginning in 1976, we attempted to obtain Federal government support for this research, but we were unsuccessful. We were nonetheless persistent, keeping the project going for two more years with our own funds and funds from our respective institutions. In 1978, the Department of Interior's Bureau of Land Management (BLM) funded a four year research contract to study fertility control in feral horses. Despite the positive results that emerged from this endeavor, considerable sputtering and indecision hallmarked the issue from 1982 to 1985. Finally in 1985, after extended rumination, the BLM issued a formal statement declaring intention to pursue chemical fertility control as a potential management tool.

Before plunging into the details of feral horse fertility control, let us place this subject in perspective with respect to the larger issue, feral horse population management. One of the problems we have experienced in the past is the invalid belief system that the goal of fertility control research was to develop a program that would: 1) permanently sterilize horses, eventually eliminating them and 2) take the place of the round-up and adoption (Adopt-A-Horse) program. Neither of those two beliefs were correct. Firstly, fertility control would be used to moderate population growth, not terminate it. Secondly, fertility control would be used in conjunction with the round-up and adoption program, according to individual range needs and public demand for excessed horses. Without a doubt, multiple-method management is a philosophy far superior to "one fits all". With this in mind, let us examine fertility control in feral horses.

What are the characteristics of an ideal wildlife fertility control agent? Important characteristics are presented in Table 1. Firstly, it has to be effective. Effectiveness in a wildlife species doesn't have to be 100% as it does in humans. For example, an 80 percent or greater effectiveness is reasonable, since the goal is not to eliminate population growth but to moderate it. Of course, the highest percentage effectiveness yields the best cost efficiency. Secondly, it has to be safe, both for the administrator of the agent and for the animals receiving it. Thirdly, it has to be reversible. This is an extremely important point. As discussed elsewhere in this symposium, the gene-

Author's address: [1]Department of Physiology, Medical College of Ohio, Toledo, Ohio 43699. [2]Department of Biological Sciences, Eastern Montana College, Billings, Montana 59101.

TABLE 1

Characteristics of the Ideal Wildlife Fertility Control Agent

1. Effective
2. Safe
3. Reversible
4. Inexpensive
5. Flexible Duration
6. Remote Delivery

tic pool in each herd exists in a dynamic state with each reproductively active animal having the potential to influence the pool. The natural selection process can occur only if a fertility control program is reversible. If it is irreversible, then genes of each treated animal will be permanently and arbitrarily removed from the pool, i.e. unnatural selection. The issue of preference for arbitrary versus natural selection cannot be dealt with here, although it ultimately is a serious consideration of population management. Fourthly, the ideal agent will be inexpensive. That is simple economics. It has to be cost-competitive. Fifthly, it should have a flexible duration so that a single treatment can act for at least one complete breeding season and perhaps several. This will enhance adaptability for needs of various ranges. Finally, the agent should be administerable by remote delivery, i.e. without capture or chemical immobilization of the animal, thus maximizing treatment efficiency and minimizing danger to and harassment of the horse.

Let us now examine the fertility control methodologies which are currently available and their potential for use in feral horses. How can a female be made infertile? Table 2 lists several possiblities. Firstly, ovulation can be prevented. Secondly, transport of the ovulated egg to the uterus can be disrupted. Interference with transport can prevent implantation and fertilization. Thirdly, implantation can also be prevented by the presence of an intra-uterine device (IUD). Fourthly, estrus behavior can be prevented, thus eliminating sexual attraction of the male to the female. Finally, the ovaries can be removed.

The methods for making a male infertile (Table 2) are in principle very similar to those for making a female infertile. Sperm production and/or motility can be prevented. The transport of sperm through the male tract can be abolished by vasectomy. Sexual behavior in the male can be prevented, so the male doesn't breed with the female. Finally, the testes can be removed from the male.

Which of the methods harbor promise for feral horse fertility regulation? Table 3 offers several considerations. Removal of the gonads is not acceptable. It requires capturing the animal and surgical procedures and is

TABLE 2

Methods for Producing Infertility In Males and Females

Ways to Make Males Infertile	
1. Inhibit sperm production and motility	(chemical)
2. Block sperm transport	(vasectomy & chemical)
3. Prevent sexual behavior	(chemical)
4. Castration	
Ways to make Females Infertile	
1. Prevent ovulation	(chemical)
2. Disrupt transport of egg	(ligation & chemical)
3. Prevent implantation	(IUD & chemical)
4. Prevent estrus behavior	(chemical)
5. Ovariectomy	

irreversible. Those are all unacceptable as characteristics of antifertility agent. Ligation of the uterine tubes or vasectomy are unacceptable on a large scale also because they require capturing the animal and surgery and are generally irreversible. Even if the method were reversible, the reunion of the vas or tubes would require another capture and surgery. Thus, this method is unrealistic unless permanent sterility is the goal.

Inhibition of sexual behavior is an untried method. Too little is known about this in the female to make a solid prediction. However, considering how closely tied breeding is to the band social structure, it seems likely that lack of

TABLE 3

Considerations for Fertility Control In Feral Horses

METHOD	CONSIDERATION	REASON
Removal of gonads	Unacceptable	Requires capture and surgery and is irreversible
Ligation or vasectomy	Unacceptable	Requires capture and surgery and is irreversible
Inhibition of sex behavior	Unacceptable in male Unknown in female	Also would inhibit harem behavior, threat to herd social structure
Chemical inhibition of gamete production and/or movement	Acceptable	Can satisfy most requirements for ideal agent

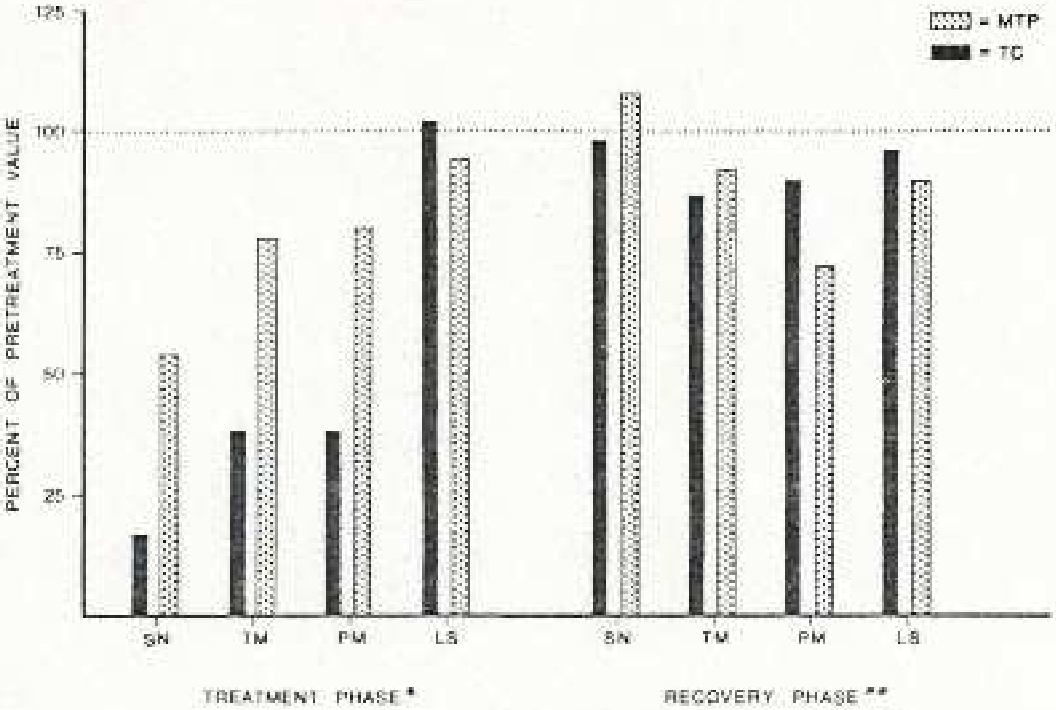

Figure 1. Effect of two different male sex hormone preparations on semen parameters and libido in domestic ponies. MTP = microencapsulated testosterone propionate, TC = testosterone cypionate, SN = total sperm number, TM = total sperm motility, PM = progressive sperm motility and LS = libido score. This study was supervised by Dr. R.M. Kenney and Dr. V.K. Ganjam at the University of Pennsylvania, New Bolton Center.

breeding would eventually prove disruptive to the band structure, unless only one or two of several females in a given harem were sexually inactive across the breeding season. Inhibition of sexual behavior in the male is definitely unacceptable. In feral horse populations, harem structure is the rule. As demonstrated earlier in the symposium, it appears that the same hormone controls both sexual behavior and some harem maintenance behavior. Thus inhibition of libido will result in lack of interest in the harem as well, potentially leading to takeover of the harem and breeding of the harem mares by untreated males.

Chemical inhibition of the production or movement of gametes is one method that has possible acceptability. it has the potential for satisfying most or all of the requirements for an ideal contraceptive agent, and it deserves investigation. A detailed, current review of the subject of chemical fertility control for wildlife species is available.[2]

The first, and presently the only completed study of chemical fertility control in feral horses has been carried out by Kirkpatrick and Turner and was directed at stallions. The results of this study have been published.[3] In the initial phase of the stallion study, the male sex hormone testosterone was tested in two different formulations (Testosterone cypionate (TC) and microencapsulated testosterone propionate (MTP) in pony stallions at the University of Pennsylvania. The details of this study have been previously published.[5] Within 6-8 weeks after treatment initiation, significant decreases from control values occurred in sperm number and sperm motility, while libido scores remained normal (Figure 1). These effects persisted for approximately 6 months (treatment phase). In the recovery phase, which was two months after the treatment effect had disappeared, sperm number in both types of treatment had returned to normal, motility returned to the range of normal and the libido score was still in the range of normal. No side effects were observed. Thus it appeared that these agents were potentially useful for safe, effective and reversible fertility control.

In this preliminary study, the treatment decreased sperm production but did not compromise the normal sexual behavior of the male. Theoretically, in a field study, the stallion given this treatment would still maintain his harem but wouldn't be fertile. The next obvious step was to administer the agent in the field. MTP was chosen for the field trial on the basis of its more extended action in a single injection. The MTP, prepared by Southern Research Institute (Birmingham, Alabama), consisted of microdroplets of testosterone propionate coated with a biodegradable polymer of varying thickness. The basic principle is that the thicker the coating is, the longer it takes for the coating to be biodegraded and therefore the longer it takes for the drug to be released into the circulation. By varying the thickness of the coating, it is possible to have release times ranging from several days to 5 or 6 months, and by including the whole range of coating thicknesses in a single injection, release can be continuous throughout

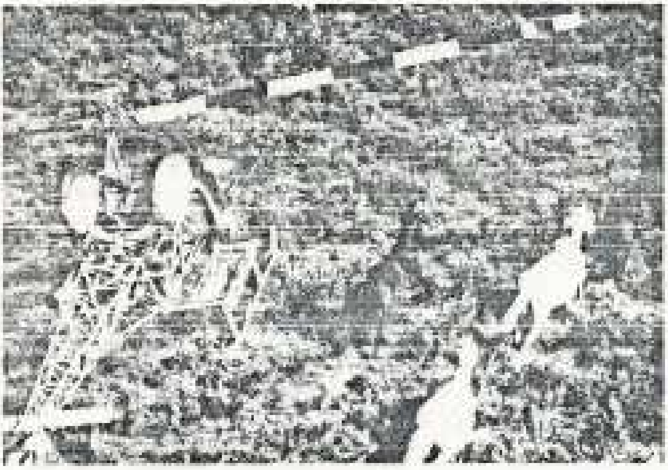

Figure 2. Feral horses are followed by helicopter at close-range in a study to establish feasibility of remote darting.

TABLE 4

Foaling Data for Hormone-treated and Control Bands in 1981 and 1982

	1981		1982	
	Control	Treated*	Control	Treated*
# of foals/ mare	0.371	0.066	0.362	0.414
# of foals/ band	0.62	0.28	0.87	0.85
% of bands with foals	87.5	28.4	85.8	83.3

*Antifertility agent was administered prior to 1980 breeding season.

this period. The current technology is being refined and should soon provide a preparation with up to an 18-month release period capability.

In the initial field study, the animals were immobilized and then the drug was injected directly by syringe to be certain that all of the dose was in the animal. However, more recent studies (unpublished) have documented that the drug can be administered remotely without doing the intermediate immobilization step. Thus the animal does not have to be immobilized or captured. For a large scale fertility control program it would be most efficient to fly over the horses with a helicopter and deliver the treatment remotely via a dart gun (Figure 2). With the benefit of a skilled pilot the dart can be delivered to a horse at full gallop. In our own experience, the skid of the helicopter has consistently been placed and maintained within 15-20 feet of the horse's flank, even in mountainous terrain. This situation does not require a skilled marksman.

The results of the initial field study are presented in Table 4. The treatment was given to 10 harem stallions prior to the 1980 breeding season. In the 1980 breeding season, the male should have been infertile. The data comparing 1980 and 1981 foalings indicated that this was the case. In the summer of 1981 there was a decrease of more than 80% in the number of foals per mare in the treated bands. No decrease occurred in untreated bands. In the following year, 1982, the number of foals per mare in control bands was similar to the numbers in 1980 and 1981, and the foal counts in the treated bands had returned to pretreatment (1980) levels. In other words, the treatment was reversible. On the basis of these data, it was concluded that a single injection of microencapsulated testosterone propionate given several months prior to the breeding season: 1) did not interfere with mounting, copulation or elimination marking behavior in the stallions (based on behavioral observations as described previously in this symposium); 2) significantly decreased the fertility relative to untreated controls for a single breeding season and 3) permitted a return to normal fertility in the breeding season of the following year.

In the previous study the stallion was chosen as the target sex on the premise that males keep a harem averaging 5-6 females, and therefore treatment of males should be more efficient. As Dr. Kirkpatrick has pointed out earlier in the symposium, the vast majority of feral horse herds have a single dominant male breeding the harem, and the above premise would be correct. However, in some horse ranges breeding by subordinate stallions in a significant percentage of bands has been reported, as well as some interchange of mares between bands. Although treatment of both dominant and subordinate males in a given band would address the former issue and the randomization of treatment across years would address the interchange issue, it is nonetheless worthwhile to pursue the basic principle of chemical fertility control in mares. Perhaps the most convincing reason for this lies in the possibility for providing an additional dimension of flexibility in population management of specific ranges.

Toward this end, there have been two studies of female fertility control initiated (Table 5), one of which has nearly been completed. This latter study has been privately funded and was performed by Dr. Erwin Liu at the Unversity of California, Davis. It was an immunological treatment. An antiserum injected into mares several times over a period of months interfered with the fertilization of the egg rendering these mares infertile. Based on a sample of 15 mares, 93% were infertile as evidenced by the reduced number of foals in the following year. The treatment was effective for one breeding season. Reversibility has not been reported. However, it is likely that the effect would be reversible in the absence of continued booster treatments of antiserum. One of the disadvantages of this immunologic treatment at present is that it requires multiple injections (up to 4) over the course of the breeding season. This approach is worthy

TABLE 5

Current Chemical Fertility Control Technology for Consideration in Wild Horses

Sex	Treatment	Route	Effectiveness	Reversibility	Duration	Researchers
Male	Microencapsulated testosterone propionate	Injection	83% (N=10)	Complete	One Breeding Season	Kirkpatrick & Turner
Female	Immunologic	Injection	93% (N=15)	Unreported	One Breeding Season	Liu
Female	Silastic rods of estradiol & progesterone	Capture, incision implant	Unknown	Unknown	Unknown (up to 3 years)	Tester, Siniff & Plotka

of further studies to reduce treatment frequency, since it has the advantages of safety, absence of behavioral effects, remote delivery capability and potentially very low cost per animal.

A second study which is now being performed by researchers at the University of Minnesota, with funding from the BLM, is investigating the use of hormone implants to regulate female fertility. Various combinations of the female sex hormones, estradiol and progesterone, (similar to those used in birth control pills), will be impregnated into silastic polymer rods and subcutaneously implanted. This procedure, to be evaluated in 6 groups of 30 mares each, involves immobilization of each mare, making an incision under the skin and inserting the hormone-impregnated polymer. Although this study is underway, no data are available at the present time.

Despite the fact that microencapsulation technology has been used in males and silastic implant technology is being used in females, both methods could be used in either sex. Of course, an important consideration is whether one is more advantageous than the other. For example, does one technology exhibit more of the characteristics of an ideal contraceptive than does the other technology? Let us look at aspects of microencapsulation versus silastic implants (Table 6). Microencapsulation has one characteristic that is very important in considering long term fertility control in feral horses. Remote delivery is possible. Silastic implants cannot be delivered remotely. Administration of silastic implant rods requires surgical incision and therefore also requires capture and/or immobilization of the animal. Thus the feasibility of the silastic implant method, at least as currently performed, for use on the large scale and over the long term is questionable. A disadvantage of the microencapsulation system presently available is the limited period of treatment effectiveness, one breeding season. The recent BLM policy statement addressing fertility control indicates preference for a minimum of two years effectiveness. In this regard, the silastic implant method has been demonstrated in other species to release hormone for at least two years. However, with recent refinements in microencapsulation technology, it appears that time-release of hormone over a period of two years is possible. Thus on

TABLE 6

Consideration of Microencapsulation and Silastic Implants as Delivery Methods for Antifertility Agent

Method	Characteristics		
	Route of Administration	Effective Lifespan	Disturbance to Animal
Microencapsulation	Remote delivery by dart	1 year	Minimal
Silastic implants	Capture and surgical incision	2 or more years	Extreme

TABLE 7

Cost-efficiency Comparison of Fertility Control versus Adopt-A-Horse (For Herd of 500)

	Fertility Control	Adopt-A-Horse
Frequency	Annual or Alternate Years	Alternate Years
Personnel	2-3	30
Work hours	12-15	30-40 (round-up) > 100 (adoption)
Man-hours	36-45	900-1600 (round-up) > 500 (adoption)
Equipment	Rifle, darts, drug and helicopter	Trap fence, corrals, trailer trucks, saddle horses, helicopter and communication equipment
Average annual cost per horse	$50	$300-$400
Horse harrassment	Minimal	Extensive

the basis of the high efficiency (low cost and time) and minimum intrusion on the horses associated with the remote delivery method, continued research on the micro-encapsulation format for antifertility agents is warranted.

As stated previously, we do not advocate fertility control as a replacement of round-up and adoption. However, with many already-captured horses still unadoptable it is apparent that the Adopt-A-Horse program alone cannot keep pace with population growth. Furthermore, as several presentors in this symposium have already documented, round-up and adoption is expensive and time consuming and is a major harassment to the horses. In contrast, fertility control, especially using a remote delivery system, may be none of these. An examination of Table 7 may clarify this point. Based on data gathered during our own research and on BLM reports from Idaho round-ups in 1980 and 1983, a rough comparison of fertility control and gathering-adoption has been made. Regarding frequency, the latter is done every 2-3 years depending on the specific range. Fertility control would be given annually now if it was delivered remotely but technologically it has the potential for being given in alternate years. The number of personnel required for the fertility control includes a helicopter pilot, a shooter to administer the drug (dart) and an assistant to facilitate loading of darts and photographic record keeping. With a target hit success rate of 4-6 stallions per hour, which has been documented, zero population growth could theoretically be achieved with about 15 hours flying time. In marked contrast, the round-up and adoption program may required up to 30 personnel working 30-40 hours in the round-up and several personnel working more than 100 hours in the adoption phase (reported elsewhere in this symposium to be the most expensive part of the Adopt-A-Horse program), to accomplish a maintenance of zero population growth. In converting to man-hours, the difference between the two methods becomes even greater. This trend continues when the equipment costs are included and would be further exaggerated when per diem and lodging and travel are added.

At present, a reasonable projected estimate for the cost of male fertility control for a herd of 500 horses would be $50 per horse per year, whereas for the Adopt-A-Horse program, it would be $300 to $400 per horse per year. Several associated considerations deserve attention here. Firstly, zero population growth is not a goal. It was used as an example to simplify analysis. In practice, a less rigorous limitation of population growth would be chosen. Secondly, the cost for fertility control would probably be somewhat greater if mares were treated, since more horses would have to be treated. However, this increase would be considerably moderated by the fact that many more mares than stallions can be treated in an hour of flying. Thirdly, the cost per horse for both methods, but especially for Adopt-A-Horse, will vary considerably among ranges. The present estimate for Adopt-A-Horse is rather conservative. Finally, an often neglected but major consideration is the relative harassment experienced by the horses with each method. Think about that one.

In closing, let us be aware that this conference is really the first of its kind, bringing together individuals representing varied perspectives of the wild (feral) horse issue. The last scientific gathering in the realm of wild and feral equids was in 1979, in Laramie, Wyoming.[1] This meeting, designed from a broader perspective, has perhaps accomplished an integration of facts and ideas that has long been needed and desired. And though there can be no doubt that we all care about these horses and their future or we wouldn't be here, we must realize that the horses represent only one facet of a very, very big problem that is developing on this planet; wildlife overpopulation on limited preserves. Or, if we may reflect selflessly for a moment, human compression of wildlife space is the problem. Whatever way we want to look at it, it is nonetheless an ominous reality in ranges and preserves all over the world. We have got to educate people in this issue. We have got to institute a means for rebalancing the ecosystems which we have disrupted in the ignornant belief that man owns this planet. Today is one spark toward such enlightenment.

REFERENCES

1. Denniston RH: (Ed.) *Proceedings of the Symposium on the Ecology and Behavior of Wild and Feral Equids*. Laramie Univ of Wyoming Publ, pp 236, 1979.

2. Kirkpatrick JF, Turner JW Jr: Chemical Fertility Control in the Management of Wild and Feral Species. *Biosciences* 35(8):485-491, 1985.

3. Kirkpatrick JR, Turner JW Jr: Seasonal Ovarian Function in Feral Horses: Seasonal Patterns of LH, Progestins and Estrogens in Feral Mares, *Jour Eq Vet Sci* 3(4):113-118, 1983.

4. Turner JW Jr: Given a Free Rein, Prolific Mustangs Gallop into Trouble. *Smithsonian* 14(11):88-96, 1984.

5. Turner JW Jr, Kirkpatrick JF: Androgens, Behavior and Fertility Control in Feral Stallions. *Jour of Reprod Fert (Suppl)* 32:79-87, 1982.