Chemical Fertility Control and Wildlife Management

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Chemical fertility control is a neglected yet potentially powerful wildlife management tool that represents an effective, inexpensive, and humane alternative to current control methods. A large number of new contraceptive agents, designed primarily for use in humans, can be administered remotely by injection to large mammals or orally to smaller animals. These compounds will not cause death, do not disturb social order, and can be manipulated to protect nontarget species.

Uncontrolled or poorly controlled increases in wild and feral animal populations are a problem today in many parts of the world. Protection afforded certain species through refuges, as for the elk herd in Yellowstone National Park, or through legislation, as for feral horses and burros in North America, has resulted in animal herds that exceed the land's carrying capacity. In other cases, population control is needed for predatory species (coyotes), to prevent the spread of communicable or contagious disease (skunks), or because of diminished habitat (elephants).

Traditionally, these population increases among wild and feral species have been controlled through hunting, trapping, relocation, and poisoning. Controlled hunting, although successful in certain cases, is coming under increased public scrutiny. Trapping, particularly with leg-hold devices, is extremely unpopular among certain segments of society, and legislation against steel traps has been passed or is pending in many states, provinces, and even countries. Live-trapping and relocation of overpopulated species is expensive and works only where sufficient suitable habitat exists. Poisoning overpopulated animals is distasteful, often dangerous to humans, and notoriously nonspecific. Most poisoning programs require permission from governmental agencies like the Environmental Protection Agency before the program may begin. The shortcomings of poisoning are multiple and serious. First, the target animals are destroyed in a less-than-humane fashion, healthy animals along with diseased ones. Second, population reduction is only temporary, and each new breeding season results in new increases. Third, the poison kills nontarget species.

With the notable exception of the rat, the concept of chemical fertility control as a means of controlling wild and feral populations has received surprisingly little attention despite a significant backlog of research predicting success. Thus the concept, which is not entirely new, is

"It says here that we eat these cabbages for 21 days and then we eat . . ."

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largely untested, and skeptics often consider the approach bizarre. The technology associated with chemical fertility control in humans is impressive, and its application to wild or feral species is fundamentally sound. The compounds available for use in humans were first tested on other animals. The remainder of this paper reviews the history of this line of research and some recent advances, suggests directions for future research, and discusses the benefits of chemical contraception in wild and feral species.

HISTORY

Canidae

The use of antifertility compounds in canids was prompted by the discovery in 1953 that mismated bitches could be induced to resorb the embryos if treated with the synthetic estrogen diethylstilbestrol (DES) (Jackson 1953). Linhart (1963) proposed the use of steroid antifertility agents to control red fox (*Vulpes fulva*) populations and sylvatic rabies. A year later, Linhart and Enders (1964) demonstrated that female foxes force-fed 50 mg of DES from nine days before mating to ten days after mating became infertile. DES apparently acted by causing implantation failure or early embryonic death. The same dose of DES had no significant effects upon male foxes.

At about the same time, Balser (1964) attempted to control coyote (*Canis latrans*) populations with DES. Initial laboratory tests had shown that DES given just before or after mating inhibited implantation in coyotes just as it had in foxes. Tallow baits filled with 100 mg of DES were dropped in certain sections of New Mexico. Female coyotes caught several weeks later showed signs of reproductive failure. Approximately 75% of these females showed implantation failure or fetal resorption.

There were, however, limitations in the effectiveness of DES baits for inhibiting fertility in coyotes. First, DES ingestion had to be timed relatively precisely in the coyote reproductive cycle for success. This problem was compounded by the fact that coyotes did not take nonliving baits with any regularity during the breeding season. There also appeared to be some problem in the absorption of the DES in tallow baits. Finally, Balser (1964) reported that coyotes that did take the DES-drugged bait appeared to remain sexually active longer than usual and were thought to be reproducing later in the season.

Since Balser's work with coyotes, research on contraception in canids has been redirected to domestic dogs. Taking advantage of advances in reproductive endocrinology, Simmons and Hamner (1973) placed silicone rubber implants containing testosterone or androstenedione subcutaneously in female beagles. The bitches were kept in constant anestrus for 420 to 840 days; when the implants were removed, normal fertility was restored. Estrus was clearly suppressed in these dogs, but this study did not identify the actual mechanism of action. The most probable explanation was that the androgenic steroids had interfered with the hypothalamic-pituitary axis, blocked the release of luteinizing hormone (LH) and follicle stimulating hormone (FSH), and inhibited follicle stimulation and/or ovulation. Unfortunately, in addition to producing infertility, the androgenic steroids caused masculinization and altered the behavior of the female in a manner unacceptable to dog owners.

A crucial issue in all long-range wildlife population management programs is whether the cure for the problem is worse than the problem.

Shortly thereafter, other investigators explored using oral progestins for controlling fertility in canids. Melengestrol acetate, an oral progestin, was given to bitches in doses of 200 μg or more per day, and all estrus activity was inhibited for a treatment period of 243 days (Sokolowski and VanRavenswaay 1976). The positive results obtained with melengestrol acetate led to the first progestin approved for commercial use in dogs. The compound, megestrol acetate (Ovaban, Schering Corp., Kenilworth, NJ), is an effective oral contraceptive in the bitch, highly reliable, and with few side effects (Wildt and Seager 1977). At about the same time in the Netherlands, another synthetic progestin, 14 alpha,17 alpha-propylidene-dioxy-progesterone, (proligestone) was tested in dogs; it suppressed estrus in 97% of the bitches fed the compound (VanOs and Oldenkamp 1978).

Following these successes, attention returned to androgenic steroids. The synthetic androgenic steroid 17-beta-hydroxy-7 alpha,17-dimethylester-4-en-3-one (Mibolerone) given orally to bitches for 240 days suppressed estrus and probably ovulation for the entire test period without the objectionable masculinization seen earlier with testosterone (Sokolowski and Zimbelman 1976).

Following the work of Linhart and Enders (1964) and Balser (1964), Cheatum & Hansel[1] investigated the efficacy of several different reproductive inhibitors in a colony of red foxes during four annual breeding seasons; three of the compounds studied were found to be effective. Various mixtures of clomiphene isomers [1-(p-beta-diethylaminoethoxyphenyl)-1,2, diphenyl-2-chloroethylene] given at weekly intervals throughout the breeding season did not interfere with the occurrence of estrus or mating but prevented pregnancies in all vixens receiving it. The data suggested that clomiphene may have impaired fertilization, but the mechanism of action was not described.

Diethylstilbestrol given in meat baits on the day of mating or ten days thereafter prevented implantation in vixens. However, if the DES was administered in tallow, rather than meat, it lost its efficacy. The choice of bait is clearly important when attempting to deliver synthetic steroids to carnivores. Chlormadinone acetate (6-chloro-6-17-acetoxyprogesterones) administered orally every four, seven, or ten days prevented estrus in most vixens until the feeding regimen was halted.

One of the most important features of the Cheatum and Hansel study was an attempt to inhibit male fertility. Spermatogenesis in male foxes was inhibited by feeding them a mixture of DES and chlormadinone acetate in meat baits at seven-day intervals for four weeks, beginning the first week in December. Five weeks after drug administration was discontinued, spermatozoa were present in the seminiferous tubules but not in the epididymides. No significant impairment of spermatogenesis was observed with each of these compounds alone at the same dosages.

The study of foxes by Cheatum and Hansel and the study of Linhart and Enders (1964) also demonstrated that a

[1] E. L. Cheatum and W. Hansel. 1967. Ralses control by inhibition of fox reproduction. Unpublished ms., Cornell University, Ithaca, NY.

synthetic estrogen related to DES, mestranol (3-methyl ether of ethinyl estradiol), was an effective reproductive inhibitor. No foxes fed MES for five days after mating produced pups. Although most first feedings of mestranol were readily accepted, the vixens only nibbled at subsequent drugged feedings. Thus it appears that MES could not be disguised for prolonged administration to foxes and probably not to coyotes either.

A somewhat different approach to canine fertility control was taken by Al-Kafawi et al. (1974). This team attempted to immunize dogs against their own luteinizing hormone with injections of human chorionic gonadotropin (hCG). The experiment failed because canine gonadotropins and hCG did not cross-react, but the concept was promising. A year later Faulkner et al. (1975) reported varying degrees of success in immunizing dogs against LH through the use of antibodies that were considerably more specific for canine LH.

Aves

Antifertility research in birds is somewhat more limited. Davis (1959) demonstrated that testis weights and spermatogenesis could be reduced in starlings (*Sterna vulgaris*) by feeding the compound triethylene melamine (TEM). He then suggested that the broad concept of population control through chemical gametocides be applied to wildlife management (Davis 1961). Following up on the concept, Vandenbergh and Davis (1962) showed that TEM could inhibit reproduction in breeding populations of red-winged blackbirds (*Agelaius phoeniceus*). Testis weights were reduced in TEM-treated males, and meiosis was also inhibited; however, the drug's extreme toxicity precluded practical application. Following this, Elder (1964) demonstrated that Provera, an oral progestin; Arasan, a common fungicide and seed disinfectant; and the anticholesterol agent SC-12937 (22,25-diazacholestanol dihydrochloride) all brought about reversible inhibition of ovulation in pigeons (*Columba livia*). More recently, Lacombe et al. (1984) showed that the compound ornitrol (20,25-diazacholesterol dihydrochloride) inhibited testes growth in red-winged blackbirds, but only if it was fed at precise times in the reproductive cycle of the birds.

Felidae

It had been shown as early as 1963 that synthetic progestins could suppress estrus in female cats (Harris and Wolchuk 1963). The precise form of the compound and dose were refined, and by 1976 the progestin megestrol acetate was routinely administered to domestic cats to suppress estrus (Burke 1977). Megestrol acetate was next applied to feral cat populations in England with success (McDonald 1980, Remfry 1978).

Seals et al. (1976) used injectable medroxyprogesterone acetate and melengestrol acetate in silastic implants in captive African lions (*Panthera leo*), tigers (*Felis tigris*), leopards (*F. pardus*), and jaguars (*F. onca*). Long-term suppression of estrus resulted in complete inhibition of reproduction, yet when the drugs were removed, fertility was restored.

In any wildlife fertility program it is unreasonable and probably unwise to attempt zero population growth.

Steroid fertility control in large cats is being applied in Etosha National Park in Namibia, where African lion populations are getting out of hand. In this case, depot progestins in silastic implants have been placed in female lions in an effort to slow reproduction (Chadwick 1983).

Chan et al. (1981) took an immunological approach to fertility control in cats. They homogenized feline ovaries and raised rabbit antibodies against them. The antibodies, when administered to pregnant cats, caused some fetal resorption, but results were in general discouraging. Once again, as in dogs, nonspecificity in the antibody appeared to be the problem.

Cervidae

There has been some interest in fertility control in ungulates also. Between December and March, Greer et al. (1968) administered DES intramuscularly to 36 pregnant cow elk (*Cervus canadensis*) from the northern Yellowstone National Park herd. Doses of 75–200 mg terminated pregnancy in 30% of the treated animals. Following this, Harder (1971) and Harder and Peterle (1974) fed DES to female white-tailed deer (*Odocoileus virginianus*) before and during pregnancy; in both cases there was significant fetal loss. The intramuscular approach was more effective but clearly impractical in animals as secretive as white-tailed deer.

A year later Bell and Peterle (1975) implanted both synthetic estrogen and progestin in white-tailed does during pregnancy. The implants were clearly superior to injected steroids; pregnancies ended in a significant number of treated does. Matschke (1977a) administered DES orally to female white-tailed deer in an encapsulated form. Doses of 500–1000 mg encapsulated in a modified gelatin interrupted pregnancy in a high percentage of cases. However, poor acceptance by the does, the need for very high doses, and postabortion pregnancies led Matschke to conclude the approach was not practical. Matschke (1977b, c) then studied two synthetic progestins, MGA (17 alpha-acetoxy-6-methyl-16-methylene-4,6,pregnadiene-3,20-dione) and DRC 6246 (17 alpha-allyl-17-beta-hydroxy-3-oxoestra-4,9,11-triene). Does were given 50 mg and 1.0 g daily doses of these drugs, respectively, during the breeding season. Although does accepted both compounds without difficulty, neither prevented or delayed conception. Matschke (1980) hypothesized that not enough of the steroids accumulated in the animals' body fat to bring about prolonged action.

Roughton (1979), also realizing the impracticality of implants in deer, fed 0.6–1.0 mg of melengestrol acetate per head daily to white-tailed does during the breeding season. Reproduction was completely inhibited, there were no untoward side effects, and fertility was later restored. To be effective, however, the drug had to be given daily, a requirement that may be difficult to meet in wild populations.

Rodentia

The concept of chemical fertility control for managing pest rodent populations was originally put forth by Howard (1967). Marsh and Howard (1969) fed 0.05% mestranol baits to wild rats (*Rattus norvegicus*) and observed an immediate and significant reduction in pregnancies. Poor bait acceptance of the synthetic estrogen gave short-lived results. Following this study, Howard and Marsh (1969) and Storm and Sanderson (1970) expanded this line of research to include voles (*Microtus californicus, M. montanus,* and *M. pennsylvanicus*). Again, rats did not accept mestranol baits well, and doses had to be reduced

to 0.005% before voles would accept baits regularly. Reproduction was inhibited in the voles, and pups receiving mestranol through the mothers' milk never developed sexually, becoming irreversibly sterile.

Brooks and Bowerman (1971) and Mischler et al. (1971) evaluated a new powerful estrogenic compound, 17 alpha-ethynylestradiol-3-cyclopentyl ether, later known as Quinestrol. This compound was shown to be more effective than mestranol for antiovarian treatment in rodents. Doses as low as 10 μg completely inhibited reproduction, but once again poor bait acceptance in rats made the approach impractical.

At present, only one drug has been successfully tested as an antifertility agent in rodents and carries FDA approval for that use. Ericsson (1975) fed Norway rats alpha-chlorohydrin (3-chloro-1,2-propanediol). The drug was lethal in both sexes if ingested in high enough quantities (LD_{50} 164 mg/kg body weight) but also caused permanent sterility in male rats at sublethal doses. The drug causes a blockage at the head of the epididymis, which prevents spermatozoa from leaving the testis. The sterilized male rats are otherwise healthy and mate normally, although without results.

Once alpha-chlorohydrin enters the rat, normal metabolism, bacterial degradation, and contact with water reduces the drug to water, CO_2, and chloride; nontarget species that might catch and eat a drugged rat will thus suffer no consequences. The drug, now marketed commercially (Epibloc, Pestcon Systems, Inc., Alhambra, CA) is microencapsulated in a vinyl resin–based wall material, and bait acceptance has not been a problem. Because it is toxic and its antifertility effects are permanent, alpha-chlorohydrin has limited use in wildlife management but is clearly useful for controlling certain pest rodent species.

Recently, Garrett and Franklin (1983) successfully inhibited reproduction in black-tailed prairie dogs (*Cynomys ludovicanus*) in Wind Cave National Park by feeding DES-treated oats (0.11% active ingredient). Reproductive inhibition was almost 100% effective, and there was total reversibility when drug treatment was withdrawn.

Equidae

With a few notable exceptions, the concept of managing wild and feral populations through fertility control has focused on females. However, in certain species where harem-like groups exist, greater efficiency could come from causing infertility in the male, provided that sexual behavior were not significantly altered.

Recently Kirkpatrick et al. (1982), Turner and Kirkpatrick (1982), and Turner (1984), reported successfully inhibiting reproduction in feral horses (*Equus caballus*) by lowering sperm counts in stallions. A microencapsulated form of testosterone propionate was injected into stallions several months before the April–June breeding season in Challis, Idaho. The poly (DL-lactide) coating permitted a sustained release, thereby causing oligospermia and impairment of sperm motility for up to six months. The stallions' behavior was unaffected and breeding took place, but there was an 83% reduction in foal production. In addition, Kirkpatrick et al. (1982) demonstrated that repeated injections of testosterone cypionate and single injections of Quinestrol could also cause oligospermia in stallions; these two drugs have not yet been field tested, however.

Two of the more obvious research needs are bait acceptance by small mammals and using long-acting injectable steroids in large mammals.

RECENT ADVANCES

From a scientific viewpoint, the future for fertility control in wild animal populations is bright. Long-acting injectable contraceptives offer the wildlife manager some of the strongest population control measures, largely because these drugs can be administered remotely with tranquilizer guns, thereby avoiding expensive capture and handling programs. Some 25–30 different commercial injectable contraceptive steroids are now available, and several new long-acting progestins show great promise. Although subdermal steroid implants have been tested with some success, the newer injectable long-acting steroids appear to work better; the steroid subdermal implants quite often result in connective tissue encapsulation and interference with drug release.

Another exciting advance, which we used in our feral horse program (Kirkpatrick et al. 1982, Turner and Kirkpatrick 1982), is the development of a biodegradable encapsulation process to permit long-term sustained release of injectable contraceptive agents (Beck et al. 1980). One successful form of microencapsulation, the DL-lactide compound, permits single injections to sustain a release of contraceptive steroids for up to several years. Such a system would be invaluable in wildlife management.

Recent advances in our knowledge of male fertility control, coupled with new antifertility agent delivery systems, present a whole new dimension to fertility control in wild species. We have successfully used testosterone alone to suppress sperm production in feral horses (Kirkpatrick et al. 1982, Turner and Kirkpatrick 1982); combinations of steroids may be even more effective. Danazol, the 2,3-d isoxazol derivative of 17-ethinyl testosterone, is very effective in reducing sperm counts in men, and progestin–testosterone enanthate combinations now under study also appear effective in reducing sperm numbers to the level of infertility (Steinberger 1980). All these compounds have reversible antifertility effects, can be coupled with new delivery systems such as biodegradable capsules, can be delivered remotely, and appear to have no serious side effects.

So far we have confined our discussion of contraceptive agents almost exclusively to steroids. The Nobel Prize–winning work of Andrew Schally and Ralph Guillemin on peptide releasing hormones in the hypothalamus opens entirely new doors to fertility control. Synthetic analogs of luteinizing hormone–releasing hormone (LH-RH) have been administered by injection and have been extremely effective in blocking ovulation (Schally 1983).

Recently Vickery et al. (1984) successfully suppressed fertility in male dogs with repeated injections of an LH-RH agonist. The agonist, [D-Nal(2)^6-LH-RH] was administered intramuscularly in doses of 10 μg/kg, and testis volume, ejaculate volume, sperm count, and sperm motility all declined for periods as long as 172 days. Libido was depressed but could be restored by testosterone implants. The results of this work were encouraging, and further research is under way.

One of the most exciting possibilities for fertility control lies in immunology.

Raising antibodies against sperm (Tung 1976) and the zona pellucida of the embryo (Glass and Hanson 1974) has been possible for some time. Since gonadotropic hormones, such as follicle stimulating hormone (FSH) and luteinizing hormone (LH), and the hypothalamic releasing hormones, such as LH-RH, are all peptides, the molecules lend themselves to possible immunological attack. Immunization to monkey FSH (Nieschlag and Wickings 1981), rodent LH-RH (Fraser 1975), and canine LH (Faulkner et al. 1975) has been accomplished with varying degrees of success. Practical applications of this approach include immunizing sheep against LH and cattle against LH-RH (Robertson et al. 1982).

Currently, however, the technology in immunological fertility control is not at the point where widespread application to wild species is possible. One problem is that immunization to LH or LH-RH in males leads to a loss of libido as well as suppression of spermatogenesis. Immunization against FSH may have potential value in males, without significant changes in sexual behavior, and immunization against all three peptides mentioned above may be effective in the female. This form of contraception can last for as long as one to three years (Nieschlag and Wickings 1981) and in most cases is reversible. One of the major hurdles to effective use of the immunological approach has been the failure to obtain sufficient quantities of pure antibodies and species-specific peptide hormones (Wildt and Seager 1977). The current advances in monoclonal antibody production by hybridomas (Goding 1980) may help solve this problem.

Still another potentially useful approach is using plant products that interfere with reproduction. A recent review (Farnsworth and Waller 1982) listed 50 plant families, genera, and species that have documented antifertility effects in males and females. Using some of these plants, particularly in managing reproduction in herbivores, deserves further consideration.

DIRECTIONS FOR FUTURE RESEARCH

Two of the more obvious research needs are bait acceptance by small mammals and using long-acting injectable steroids in large mammals. Research results to date make it clear that the control of rodent, canine, and other small animal fertility is an easy proposition *if* resistance to bait acceptance can be overcome. Encapsulating steroids in a disguised and acceptable medium may represent a profitable direction for new research. For example, Calanchi (1976) made 5-mg doses of steroid palatable to human patients by microencapsulating them; the drugs had been unacceptable in uncoated 200-μg doses.

Although we successfully delivered long-acting contraceptive steroids by darts from a tranquilizer gun (Kirkpatrick et al. 1982, Turner and Kirkpatrick 1982), the technology we used was relatively crude. All the newer injectable progestin and androgen steroids require testing in a wide array of large wild and feral species and in both male and female animals. In addition, biodegradable microencapsulation should be added to the growing list of injectable steroids to provide a larger spectrum of long-acting contraceptives.

Wildlife—its preservation and particularly its management—is more often than not a highly charged emotional issue.

If chemical fertility control is to be successful, the effects of contraceptive steroids on the length of the target species' breeding season must be carefully determined. Polyestrus seasonal breeders might well remain infertile throughout a spring and early summer breeding season, but care must be taken that the reproductive process is not just delayed. A population whose reproductive activity normally concludes in summer and is delayed to the fall will produce young that will probably not survive the winter. Such a situation would be inhumane and unacceptable.

The technology for practical immunological control lags far behind the contraceptive steroid approach, but interrupting reproduction with antibodies offers greater species-specific mechanisms of action and virtually no risk to nontarget species. The production of pure monoclonal antibodies by means of hybridomas would represent an important advancement.

A crucial issue in all long-range wildlife population management programs is whether the cure for the problem is worse than the problem. The biosystem within which each target species dwells is dynamic and flexible within certain limits. Unfortunately, in most cases we have not yet delineated those limits and must work on the principle of minimal perturbance. This means extensive preliminary studies to establish normal reproductive and behavioral patterns and then further studies to assess treatment effects. Such studies must encompass complete pharmacology of the drugs being used, including specific side effects, catabolism, and possible biological activity of the excreted metabolites that may be ingested by other species in the habitat.

Also crucial is the extent to which drugs interfere with libido and sociosexual behavior. In any wildlife fertility program it is unreasonable and probably unwise to attempt zero population growth. If males are the target and only a percentage will be made infertile, then the antifertility agent must not interfere with libido or other behavior that contributes to their success in mating. Another important consideration is the long-term effects of behavioral changes on social organization. Any potential antifertility agent must be screened for direct and indirect behavioral effects. The choice of behavioral endpoint(s) for such screening is critical; sexual behavior and at least one other behavior involved in maintaining social structure would be desirable.

The lessons learned over the past decades of research on controlling human fertility must not be lost to those who wish to apply this technology to wild species. Regardless of the safety or efficacy of a chemical fertility control agent, there are important public issues to be considered and political barriers that must be overcome before widespread success can be achieved. Wildlife—its preservation and particularly its management—is more often than not a highly charged emotional issue. Thus, a final thrust for future research should be aimed at determining whether the public will accept fertility control in wild species and how to change resistance to acceptance.

BENEFITS

Perhaps the most compelling reasons for using chemical fertility control are social. Simply, the approach is humane, and public acceptance is more likely than in the case of hunting, poisoning, or trapping. Not only is individual animal

discomfort minimized or eliminated, but there is an often-overlooked secondary humane aspect. Where hunting is forbidden by law and relocating animals is economically or physically unfeasible, overpopulation is likely to end in disease and death by starvation. Fertility control is more likely to be permitted within such protected areas.

Depending on the species involved, chemical fertility control can also bring economic advantages. Consider, for example, the cost of removing a feral horse from public lands in the United States: $600 to $1000 per animal (Rey 1975). Not only is this initial cost substantial, but the population will increase every year, necessitating an annual reduction program. The initial cost of chemical fertility control is comparatively low per animal treated, and in cases where the male of a polygamous species is the target, the cost is reduced in a way proportionate to the degree of the polygamy. In feral horses, a single treated stallion may ultimately inhibit reproduction in three to ten mares. There are long-term economic benefits as well, since well-planned fertility control programs will prevent unnecessarily large population increases, thereby reducing the magnitude of future control programs.

Chemical fertility control is a flexible management tool, permitting a large variety of control manipulations. With smaller mammals like skunks (*Mephitis mephitis*) and drugged baits, local populations can be controlled with some precision, rather than subjecting entire states or districts to a single approach. Where drugs can be delivered remotely to large animals, particular herds, bands, and even individuals can be singled out. The reversibility of the drug action adds even more management flexibility. A large and unanticipated winter kill, for example, can be offset by withdrawing drug treatment for one or more breeding seasons. Since breeding animals have not been permanently removed, herd or population size can be restored to safe levels.

While the social advantages of chemical fertility control are impressive, the biological ones are exceptional. Removing an animal from a population by hunting, trapping, poison, or relocation is permanent; the genes are lost from the pool forever. Because chemical contraception is reversible, its use within an intelligent management plan keeps the gene pool intact. This may be an extremely valuable concept where dwindling habitat results in localized overpopulation of rare or endangered species.

Another obvious advantage is the ability to concentrate upon target species without serious damage to other animals. Delivering bait to a particular species without having a variety of other animals ingesting the drug is probably impossible, but through careful manipulation of drug types and dosages, effects on nontarget species can be minimized. A dose of a particular contraceptive steroid that inhibits vole reproduction may well have no effect on foxes or eagles; more research is needed before this can be stated with certainty.

Moreover, the peak breeding season for one species often varies significantly from that of another, which makes it easier to deliver bait without interfering with nontarget species. Red foxes, for example, breed from December to March, but skunks do not begin breeding until March (Asdell 1964). Thus, a bait-delivered fertility control program could be tailored for skunks to avoid interference with fox reproduction. At very least, accidental ingestion will not kill nontarget species or, except for extremely young animals, cause irrevocable fertility loss.

Finally, chemical fertility control affords an approach that, when properly evaluated, will not influence the social structure of the animal populations involved. Since sexually mature individuals are not actually removed, or for that matter even harrassed, the hierarchy of the population is not altered unwittingly by human intervention.

Controlling overabundant wildlife populations through contraception is a potentially powerful management tool that has received surprisingly little attention. Continued human encroachment on critical habitat, coupled with increased public resistance to traditional control programs, will ultimately require new solutions to overpopulation problems. Much of the scientific knowledge necessary to provide safe, effective, and humane control is already at hand; wildlife managers must be bold enough to seek these new directions.

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