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Beyond Castration and Culling: Should we use Non-Surgical, Pharmacological Methods to Control the Sexual Behavior and Reproduction of Animals?¹

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Abstract

This paper explores ethical issues raised by the application of non-surgical, pharmaceutical fertility control to manage reproductive behaviors in domesticated and wild animal species. We focus on methods that interfere with the effects of GnRH, making animals infertile and significantly suppressing sexual behavior in both sexes. The paper is anchored by considering ethical issues raised by four diverse cases: the use of pharmaceutical fertility control in (a) male slaughter pigs (b) domesticated stallions and mares (c) male companion dogs and (d) female white-tailed deer. Ethical concerns explored include animals' welfare, the possible violation of animals' rights, including rights to life, reproduction and bodily integrity; and potential concerns about loss of wildness. We compare ethical concerns about pharmaceutical fertility control with alternative strategies for managing animals' reproductive behavior including (where appropriate) spaying and neutering, sex separation, sex sorting, culling, and doing nothing. The paper concludes that there are some cases where pharmaceutical fertility control is the best ethical choice in current circumstances; but that there are other cases where alternative choices, including doing nothing, would be ethically preferable. This suggests that in ethical terms a case-by-case approach should be taken to the use of pharmaceutical fertility control in animals.

Keywords Animal ethics • animal welfare • animal rights • animal fertility control • animal contraception • spaying and neutering

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1 – Introduction

Human attempts to control the sexual behavior and/or reproduction of other animal species have a long history. The most commonly used methods have been the castration of male mammals and birds in agricultural settings, and, more recently, spaying and neutering companion animals of both sexes. Now, however, methods of controlling sexual and reproductive behavior that make use of hormones, antibodies and other pharmacological techniques have been developed and proposed for use in animals of both sexes. These methods – like surgical sterilization before them – raise a range of ethical questions. This paper will take some initial steps to explore these questions, so far little addressed in the ethical literature.

We will first outline the primary reasons for controlling animals' sexual behavior and reproduction, and the functions that castration and spaying perform. Then we will introduce several different non-surgical, pharmacological techniques for the control of animals' sexual behavior and reproduction, focusing on methods that interfere with the effects of gonadotropin-releasing hormone (GnRH), responsible for normal reproductive function. We will describe four cases where these techniques are currently being used or trialed on animals in very different contexts, and in each case briefly outline the ethical issues these techniques raise in the specific context. Finally, we will discuss one cluster of ethical issues at stake, namely those relating to animal ethics – i.e. concerning effects on the animals themselves. In this context, we will argue that there's no "one size fits all" answer to the question raised in the title of this paper. Whether these pharmacological methods should be used depends in part on the case at issue, but also on which ethical approach is adopted.

2 – Reasons for controlling animal sexual behavior and reproduction

In most species of agricultural animals, only a small proportion of the males born are required for reproductive purposes. Male animals can still, however, be useful for multiple functions, but they also pose risks. Intact males living alongside sexually mature females generally end up fighting one another, risking serious injuries. In addition, aggressive entire males can be difficult, or dangerous, to handle, tame and train, and their drive to access females can lead to property damage. Castrated animals, on the other hand, do not engage in mating fights, and are in general more docile than their intact counterparts.

Ease of handling is important for many uses of castrated animals. In Europe, from ancient times until around 1800, castrated bulls – so-called oxen – were the main source of power for ploughs, and were widely used to pull carriages (Clutton-Brock 1992; Luff 1994); they still serve these functions in some parts of the world. Castration of stallions has long been practiced, allowing them to be used more safely and kept alongside mares. Castrating animals also provides other human benefits. Agricultural animals such as bulls are castrated because castrated animals tend to fatten better (Field 1971). Better meat quality was also a reason why cockerels or roosters were castrated (now rarely practiced, partly because the chicken breeds used for meat production reach slaughter weight before sexual maturity). And today, the majority of male piglets born in intensive production systems are castrated to prevent the taste or smell of boar-taint in pork (Malmfors & Lundström 1983).

In agricultural animals, then, castration has served to control aggressive male sexual behavior, for animals to reach slaughter weight more quickly and therefore cheaply, and to improve meat quality. Disruptive sexual behavior including roaming and urine-marking is also one key reason why male companion animals, especially cats, are castrated. These behaviors are significantly reduced, or eliminated, by castration.

Relatedly, one motivation for spaying female cats is the control of sexual behaviors associated with being in heat.

For companion animals, unowned free-roaming dogs or cats, and wild animals, however, the *primary* reason for fertility control is not so much controlling sexual behavior (though that would often be welcome) as controlling reproduction itself. In both companion dogs and cats, this has led to the widespread advocacy and practice of spaying (females) and neutering (males). However, in the case of unowned free-roaming dogs and cats, and wild animals, spaying and neutering may be impractical (although in the case of cats, there has been a growth of trap-neuter-return programs). So, population control of unwanted free-roaming and wild animals has largely been carried out by killing them, using means such as hunting, trapping and poison.

Over the past several decades, however, significant concerns have been raised over castration, spaying *and* killing as methods of controlling sexual behavior and reproduction. Some concerns are ethical, relating to animal welfare or to the killing of healthy animals (Sandøe, Corr & Palmer 2016, chs. 9 and 13). Other concerns are economic: many of these procedures, especially spaying and neutering that involves anaesthesia, are expensive. There may also be cultural concerns: Cultures in the West Indies, for example, seem to have a strong aversion to castration (Fielding, Samuels & Mather 2002). Finally, in the case of zoo and companion animals, there is often a desire for infertility to be reversible. These concerns have inspired a call to find and apply non-surgical, and for some functions potentially reversible, techniques for fertility control. A variety of such techniques are currently under investigation, being trialed, or are in use. These different techniques give rise to ethical questions that should be explored, both in comparison with current practice and available alternatives, before they are widely adopted. Several leading techniques are described below.

3 – Non-surgical, pharmacological techniques for controlling sexual and reproductive behavior

Various synthetic hormones (progestins) have been developed and trialed on female companion, zoo and wild animals since the 1950s (Kirkpatrick & Turner 1991). In low doses, these prevent conception (and thereby control fertility) and in higher doses, they block the release of the egg (ovulation) and thereby control oestrus behavior. So far, these methods have been most successful in humans where synthetic progestins, often in combination with oestrogen (“the pill”), are still widely used. In some other species, however – such as dogs and cats – the use of synthetic progestins has been found to cause uterine disease (Evans & Sutton 1989) and an increased risk of mammary tumors (Misdorp, Romijn & Hart 1990; Støvring, Moe & Glattre 1997), and they are no longer recommended for long term use (Massei & Miller 2013) although the risks may be overstated (Rogmanoli 2015). In addition, these products are not available in many markets.

Chemosterilants – substances injected into the testicles or the spermatic cord of male animals – have been developed either to prevent the production of sperm in or the passage of sperm from the testicles, thereby causing permanent infertility. However, chemosterilants may not prevent the production of testosterone, and thus potentially troublesome male sexual behavior may continue (Massei & Miller 2013). This technique is, obviously, only applicable to males, and male sterilization is likely to be less effective in terms of population reduction than a technique that targets females. Controlling populations of (for example) free-roaming dogs and cats via sterilization of males is widely thought to require nearly 100% of males to be sterilized to have a significant effect. While some chemosterilant technologies are currently available, they have not been widely

taken up – though their non-surgical and permanent nature is of particular interest to groups trying to control population size in free-roaming dogs.

Two important pharmacological methods of fertility control, already currently used in some parts of the world, either interfere with the effects of GnRH or target the ZP. Interfering with GnRH can control reproduction and sexual behavior in both sexes, while altering the ZP prevents fertilization of eggs in females.

GnRH stands for the *gonadotropin-releasing hormone*. GnRH is secreted from the hypothalamus, and regulates the release of the follicle-stimulating hormone (FSH) and luteinizing hormone (LH) from the pituitary gland. FSH causes growth of follicles in the ovary and LH causes the final maturation and release of the egg; so both are necessary for normal cyclicity. When GnRH concentrations are low, or GnRH cannot access its receptor, release of FSH and LH is reduced. This results in inhibition of follicular development, ovulation, and luteal function, and consequently the female stops cycling. In the male, sperm and testosterone production is reduced, causing infertility and suppression of sexual behavior.

Interference with the actions of the gonadotropins can be achieved in two main ways. One method is by vaccination with an anti-GnRH vaccine that causes antibodies to be formed against GnRH, which then cannot stimulate the release of FSH and LH (Thompson 2000). Another method involves high doses of a GnRH agonist. Such treatment with GnRH results in a paradoxical decrease of activity (down-regulation) of the pituitary gland and thereby results in reduced FSH and LH release (Dobson 1985; Gong et al. 1996).

ZP is an abbreviation for “zona pellucida”, a glycoprotein membrane that surrounds the egg in female mammals. Sperm binding proteins are located in the zona pellucida, which allows the binding of the sperm to the egg as part of the fertilization process. A vaccine against the zona pellucida results in an antibody-mediated interference with the sperm binding to the egg, which thereby prevents the egg from being fertilized (Kirkpatrick & Turner 1991; Gupta et al. 2011). Female animals will display normal sexual behavior after the vaccine is administered. Most commonly this vaccine is produced using pig (porcine) eggs, so it is known as PZP – porcine zona pellucida.

To allow for a targeted and realistic ethical discussion, in the following section we will outline four cases where non-surgical fertility control techniques are being used, albeit so far not very widely. The cases are drawn from different contexts: farm animals, companion animals, horses (understood as being in a grey zone between farm and companion animals), and wild animals. We will describe current standard practice, why non-surgical fertility control is being proposed as an alternative, and point to some immediate ethical issues raised by the non-surgical approach in light of standard practice. For the sake of brevity, we will only focus on techniques that interfere with the effects of GnRH. A general discussion of questions raised for animal ethics, including what should actually count as “alternatives,” will follow in the last section of the paper.

4 – Four Cases where Non-Surgical Techniques are Applied

4.1 Case 1: Immunocastration of Male Piglets in Intensive Pig Production

4.1.1 Standard practice

In most countries young male pigs are castrated (the age at which this is carried out varies between days and weeks) to prevent boar taint and reduce the possibility of injury from aggression and mounting - and in most countries this is done without anesthesia..

4.1.2 Concerns about standard practice

The practice of castration without anesthesia raises ethical concerns about both short and long term pain (von Borell et al. 2009). In some countries (e.g. Denmark and Germany) pig producers are required by law to castrate and offer pain relief simultaneously (De Briyne et al. 2016). This reduces welfare concerns about post-surgical pain, but is ineffective in reducing the pain from the surgery itself. In Norway, pig producers are required by law to use local analgesia (De Briyne et al. 2016), an expensive solution since it requires the involvement of a vet; and in the Netherlands general anaesthesia by means of CO₂ has been tried (De Briyne et al. 2016) but has been found both to be impractical and to generate further welfare problems. In some farming systems, such as the UK and Ireland, pigs are kept entire and slaughtered earlier to try to avoid aggression and boar taint. But this is not always effective, and is not useful for meat cuts that require more mature animals. In the US and in continental Europe, pig slaughter weights are considerably higher than in the UK, meaning that pigs are older when slaughtered, and taint is more likely to develop. Some attempts have been made to breed pigs without taint, but success so far has been limited, and male pigs without taint can still be aggressive. In the EU, pressure to find alternatives to castration has become intense, since the EU Commission made an agreement with key stakeholders in 2012 to end castration of piglets by the end of 2018 (European Commission 2017; for a negative assessment of the feasibility of this goal, see De Briyne et al. 2016). One possible solution could be insemination with sex-sorted semen, using sperm carrying the x-chromosome so that only female piglets are born, but this sorting procedure is still too slow for commercial purposes. For an overview of the various options and their welfare implications see Giersing, Ladewig and Forkman (2006).

4.1.3 Non-surgical pharmacological alternative

A GnRH vaccine has been registered in many countries and is available on the market in the EU and Australia. The vaccine is effective in preventing boar taint and aggressive sexual behavior in male pigs. It requires a primary injection, and then a booster vaccination. After the second injection, aggression among male pigs is reduced. The effects of the injection are temporary, and further injections are needed for pigs slaughtered at a more mature age.

4.1.4 Concerns about the pharmacological alternative

A GnRH vaccine can be administered by a non-vet after some training, which reduces the cost and inconvenience; and it is reasonably affordable. However, there are concerns about its safety for people; if accidentally injected into farm workers, the vaccine can cause infertility. Commercial stakeholders are also concerned that consumers will mistakenly fear the safety of meat from treated pigs (Huber-Eicher & Spring 2008); but evidence does not so far suggest that the use of a vaccine to control boar taint actually leads to negative consumer reactions (Vanhonacker & Verbeke 2011).

4.1.5 Ethical issues

For the purpose of this section, we will hold as a constant that the pigs under discussion are housed in an intensive farming system, are destined for slaughter, and must be managed to prevent boar taint and to limit sexual behavior. (We will question these assumptions below.) The issue, then, is whether the GnRH pharmacological solution is better than castration. In terms of animal *suffering*, the pharmacological solution is clearly preferable. It is much less painful than castration and does not require either anaesthesia or analgesia. Another possible ethical concern here is the loss of *bodily integrity* through castration; GnRH vaccinations, unlike castration, don't require any compromise of bodily integrity. A further worry concerns human beings, both in terms of accidental injection and consumer objection. But where GnRH vaccine is administered under controlled conditions by trained workers taking safety precautions, there should not be a significant risk to human welfare; and pork from pigs vaccinated with a GnRH vaccine does not pose any threat to human health, since the vaccine has no pharmacological effect if digested. So, this seems to be an ethical concern with little substance.

4.2 Case 2: *The use of GnRH Agonist Treatments in Male Dogs*

4.2.1 Standard practice

In North America, parts of Europe, and other countries, surgical castration and spaying are widely recommended as standard practice for fertility control in companion dogs. Castration is also sometimes carried out to prevent or alleviate behavioural problems, especially sex hormone-related aggression in male dogs. In many developing and middle income countries, particularly in the global South, there are significant concerns about free roaming dogs (street dogs). These concerns include both the size of dog populations, because of nuisance complaints and/or community cost to manage, and the risk of rabies from dog bites. Currently, this problem is largely dealt with by culling street dogs, frequently in inhumane ways (see Jackman and Rowan 2007 for examples). Recently, large scale spaying and neutering has been recommended, for instance by Humane Society International (2017), as a more effective and humane way of controlling population size and reducing incidents of aggression in street dogs.

4.2.2 Concerns about standard practice

Spaying, and, to a lesser extent, castration are major surgical interventions that may cause complications, especially among free roaming dogs where there is little access to post operative veterinary care. Very early sterilization may have negative effects on dogs' development, leading to higher rates of hip dysplasia, lymphosarcoma (a type of cancer), and tears in the cruciate ligament in the knee in at least some breeds (Torres de la Riva et al. 2013). There may also be long term health effects. Spaying may have positive effects on the longevity of bitches due to reduced frequency of mammary tumours (Schneider, Dorn & Taylor 1969) and removal of the risk of pyometra (infection in the uterus). But castration has several potentially problematic effects on the health of male dogs, in particular elevating the risk of prostate and other cancers (Cooley et al. 2002; Bryan et al. 2007) For both dogs and bitches, surgical sterilization raises

the risk of obesity (Lund et al. 2006), which in turn leads to health problems such as diabetes (German 2006). The evidence that castration reduces aggression in male dogs is mixed, though it may reduce roaming and urine marking in male dogs, and make some breeds more trainable (Serpell & Hsu 2005). Spaying and castration are also relatively costly, since they require both qualified veterinarians and anaesthesia. It is mainly for this reason that for street dogs, culling is standard practice. But culling raises significant welfare issues, since in poorer areas, access to pharmaceuticals that can painlessly euthanize dogs is scarce, and the use of poisons can also have effects on non-target populations, including humans. Furthermore, even if culling is painless, there may be concerns about killing young, healthy dogs, and dogs affiliated with particular communities.

4.2.3 Non-surgical pharmacological alternatives

In recent years, a number of NGOs and philanthropic initiatives, most prominently the Alliance for Contraception in Cats and Dogs, supported by a \$75 million commitment from a private American foundation, Michelson Prize and Grants, have focused on developing non-surgical methods of sterilizing dogs. The ultimate goal of these initiatives is to achieve permanent, affordable and widely available sterilization in a single treatment. There are various promising approaches in the pipeline, including methods that control GnRH either by means of a GnRH-based contraceptive vaccine or based on administration of GnRH agonists. Currently, one commercial product, Suprelorin, has received regulatory approval and is commercially available in the EU and Australasia. This product achieves temporary infertility in male dogs due to the massive release of the GnRH agonist, deslorelin. The deslorelin implant is injected subcutaneously, and the deslorelin is released for at least six or twelve months, after which a new application is required. A short period after administration of the implant, the dogs become infertile and behave as if castrated.

4.2.4 Concerns about the pharmacological alternative

The pharmacological alternative seems to be equally as effective as castration in terms of behavior and fertility control. However, the product is fairly costly, not least because at present a veterinarian is required to implant it every six or twelve months to ensure infertility. This makes it typically more expensive than castration in the long run, and unlikely to be useful for population control in street dog populations. Its primary users are likely to be relatively wealthy dog owners who either want their dog's infertility to be reversible, or who wish to see whether a dog's problematic behaviour can be changed before considering the permanent intervention of surgical castration.

4.2.5 Ethical issues

Recent philosophical work on companion animals has increasingly raised ethical concerns about surgical castration and spaying (Boonin 2003; Donaldson & Kymlicka 2011; Palmer, Corr & Sandøe 2012). Castration of male dogs may have negative health effects both in the short and the long term, as well as causing pain. It permanently prevents male dogs from performing – and wanting to perform – typical male dog behavior; if species-specific natural behavior matters for welfare, this is ethically problematic. Castration

also removes a significant part of a dog's physical anatomy, which in some ethical views violates a dog's bodily integrity.

In comparison, if deslorelin is used repeatedly on male dogs, it can be expected to have the same health effects as surgical castration (though without the direct pain and health risks of surgery). Like castration, it also prevents dogs from carrying out species-specific natural behavior. However, dogs' bodily integrity is unaffected. And deslorelin's reversible nature means that if it is ineffective in changing a dog's unwanted behavior, it need no longer be applied; and, in addition, it spares dogs surgery. So, if sterilization of companion animals is thought to be morally acceptable in principle, then deslorelin for male dogs may be more ethically desirable than castration, for those owners that can afford it.

3.3 Case 3: The Use of Non-Surgical Techniques in Domestic Horses

3.3.1 Standard practice

When not required for breeding, surgical castration of stallions is standard practice. The aim of castration is primarily behavioral: to prevent the potentially dangerous and aggressive behavior of intact stallions, and to allow male horses to be kept together with mares and other geldings. Mares are not usually sterilized, but their oestrous behavior may interfere with training and competing. Without pharmacological intervention, however, the mare would have to undergo abdominal surgery to remove the ovaries, which is not common practice.

3.3.2 Concerns about standard practice

Concerns about castration of stallions focus on loss of bodily integrity, post-operative pain, and occasional medical complications, even if castration is carried out by a vet. The only concern about the standard do-nothing practice in mares is that some owners would like tools to manage and control female oestrus, in particular when performing in horse shows.

3.3.3 Non-surgical pharmacological alternatives

Various non-surgical methods of contracepting both stallions and mares have been investigated in recent years. The synthetic hormone altrenogest, a progestin, has been used in mares to control the reproductive cycle by keeping them in an artificial dioestrus (the period where the mare is not receptive to the stallion) (Squires et al. 1979; Webel & Squires 1982), and thereby preventing estrous behavior. In the EU and Australia, a vaccine against GnRH is commercially available for mares and has been used off label for stallions. (It has also been approved for feral horses in the US, but we will not explore feral horse management further here.) The duration of the vaccine's effect varies in individual animals (Schulman et al. 2013). Mare owners may try the GnRH vaccine to see if the mare's behavior is changed for the better; if so, they could opt for permanent removal of the ovaries. Stallion owners may want the GnRH vaccine to dampen down the behavior of young stallions. These methods should not result in permanent sterility or

behavioral change, and administration must be repeated regularly. In principle, therefore, GnRH vaccines are reversible and allow horses to be bred from later.

3.3.4 Concerns about the pharmacological alternative

GnRH vaccines do not seem to be as effective as castration in terms of behavioral modification for stallions, especially in more mature stallions. Veterinarians also express some concerns about reversibility in both mares and stallions. In mares, while GnRH vaccines stop cyclicity, unwanted oestrus behavior may still be displayed due to the release of steroids from the adrenal gland. In addition, the expense of GnRH vaccines and a veterinarian's time to administer the vaccine at regular intervals make these pharmacological alternatives more expensive than castration in the long run.

3.3.5 Ethical issues

Since stallions can be physically dangerous to people and other horses, they are gelded unless being used for breeding. Currently the only realistic choices are to use castration or GnRH vaccines. The use of GnRH vaccine avoids the pain caused by castration, and although castration in stallions is carried out either with sedation or anesthesia, the area is painful for some time after the surgery. As in the case of pigs and dogs, using GnRH vaccines rather than castration also means that the stallion's "bodily integrity" remains intact. However, if the goal is to achieve permanent suppression of sexual behavior and fertility, then GnRH vaccines may be less effective than castration, increasing risks of harm both to humans and to horses. For mares, on the other hand, the normal alternative to GnRH vaccine or altrenogest is no treatment at all. Here it might be argued that the use of GnRH vaccines or altrenogest means that mares are no longer able to perform a range of natural behaviors that, although inconvenient, are not threatening. On ethical views on which natural behaviors form part of animal welfare, it would be better to accommodate the behaviors and avoid the pharmacological treatment.

3.4 Case 4: *The use of GnRH vaccines in deer*

3.4.1 Standard practice

White-tailed deer are found in high numbers in urban, agricultural and forested areas of the Eastern United States. Deer/motor vehicle accidents are frequent; browsing deer can be damaging to gardens, agriculture, forestry and resident plants and wildlife; and they are a host for ticks carrying Lyme disease (though the relation between deer and the spread of Lyme disease is contested; see Ostfeld et al. 2006). This has led to constant calls for population control. Deer populations are generally controlled by sport hunting with guns or bows, and in some cases, by targeted culls. In a few places (such as Cornell University) female white-tailed deer have been captured and sterilized, but this is expensive and not standard practice (although see Evans, DeNicola and Warren 2016).

3.4.2 Concerns about standard practice

Hunting and culling deer raises both practical and ethical concerns. In some locations with high density human populations, sport hunting is unsafe; in others, local laws prohibit guns. In addition, the primary interest of sports hunters is in antlered bucks, but hunting antlered bucks is not the most effective means of population control. Targeted culls in suburban areas are more effective in terms of population control, but are expensive, and often evoke public opposition.

3.4.3 Non-surgical pharmacological alternatives

GonaCon, a GnRH vaccine, was registered for use by the EPA on free-roaming female white-tailed deer in the US in 2009. A single dose can make a doe infertile for a minimum of one year and up to four years, but a two-shot system may give more reliable and longer term infertility (Miller et al. 2008). Because of the risk of human infertility from accidents, a GnRH vaccine must be injected by hand. The GnRH vaccine has been studied in both bucks and does, although it is only licensed for use with does in the US, and completely suppresses sexual behavior.

3.4.4 Concerns about the pharmacological alternative

Used according to prescription the GnRH vaccine is effective in preventing deer reproduction. But animals must be trapped, immobilized and marked for identification, which causes stress. This makes the process costly; it must be carried out by trained individuals (although without the expense of veterinarians); and there is little funding available for wildlife population control. For population *reduction* purposes, a very high percentage of the population must be treated, and even so realization of effects is slow. While there is considerable pressure from hunters to resist the use of fertility control to protect deer populations for hunting, hunting and fertility control can exist side by side.

3.4.5 Ethical Issues

Hunting white-tailed deer has become increasingly contentious, especially when deer populations live alongside people, and residents have become attached to “their” deer (Kirkpatrick 1999). More generally, ethical objections are expressed to the perceived suffering caused by hunting, and to the killing of healthy sentient animals, especially when this is understood as being for human convenience, rather than from necessity. As a non-lethal form of population control that causes no long term suffering, the GnRH vaccine avoids these ethical concerns. However if the vaccine is used to supplement rather than to reduce or eliminate sport hunting, ethical concerns about hunting obviously remain.

Use of fertility control on undomesticated, free-roaming whitetailed deer populations, however, raises ethical concerns not found in the other cases. Fertility control could be perceived as reducing their wildness, making them more like domesticated animals, and extending human control yet further into the non-human world. In preventing reproduction, it might also be argued, the GnRH vaccine also prevents deer from performing, or deprives them of experiencing, important species-specific natural sexual behaviors, as well as caring for young.

5 – Ethical Discussion: Should we Favour Use of Pharmacological Methods of Fertility Control out of Concern for Animals?

Here we will discuss the ethical concerns raised above more broadly and comparatively, in relation to castration/spaying, culling, sex separation, sex sorting to produce female-only populations, and doing nothing. Doing nothing, though, may require other changes – changing the conditions in which animals are kept, or changing the way humans use or control animals' lives. Our primary ethical focus here will be on the animals affected by the use of fertility control. While other significant concerns have been raised above – relating to human welfare and the loss of wildness when fertility control is used in wild populations in particular – we unfortunately don't have space to consider these further here. Further exploration of non-surgical fertility control in animals reveals, we suggest, that what we should do partly depends on the relationship humans have with the animals concerned, and partly on broader ethical commitments, for instance to animal welfare versus animals' rights.

4.1 Should we use Pharmacological Fertility Control, or Castrate/Spay?

For three of the cases considered – pigs, horses and companion dogs – standard practice for control of sexual behavior, and to a lesser extent reproduction, is castration. (We won't consider deer in this section, since as noted above surgical sterilization is not a standard management technique for deer – though see White Buffalo [n.d.] and Evans, DeNicola and Warren [2016].) The use of GnRH treatments is realistic in all three cases. Are there ethical reasons for preferring GnRH treatment to castration?

The first concern here is whether pharmacological fertility control is better than castration in terms of animal welfare. But animal welfare can be understood in different ways (see more in Appleby and Sandøe 2002; Fraser 2008). For simplicity here, we will focus on just two interpretations of welfare: one that is essentially hedonistic and concerned with animals' mental states, and one that is perfectionist, where species-specific "natural" behaviors matter (there are also forms of perfectionism according to which individual potential or what is statistically typical of a certain group of animals such as domesticated pigs is what matters, but we will not discuss these here). Often such perfectionist accounts of natural behavior are not intended to substitute for hedonistic ones, but rather to indicate an additional source of value – that is to say, welfare isn't *only* what matters from the animal's subjective point of view. It is *also* important that pigs are able to be "piggish", whether or not they actually enjoy the experience of piggishness.

Hedonistic accounts of welfare emphasize pain and pleasure, among other subjective experiences. Pain from applying GnRH treatments is thought to be shortlived and low-level, and long term physical problems are unlikely; so in the sense of physical pain, then, GnRH treatments look significantly superior to castration. Even with the use of anesthesia and analgesic, which are not always applied, surgical methods involve pain at the site of the incision, and can be the source of complications and infections (Stafford & Mellor 2005). It's worth noting, though, that in the case of spaying bitches the situation is less clear, since as noted, spaying is likely to improve long term health, and so to reduce suffering over time. This indicates that it's not

possible to give a one size fits all answer, even for physical pain; there may be cases in which castration or spaying is better over time.

In terms of other subjective experiences, such as anxiety, distress and happiness, GnRH treatments essentially have the same effect as spaying and castration. So, putting aside the difference between a surgical and non-surgical application, we should expect the same effects. Both will prevent animals from undergoing some kinds of negative experiences, such as sexual frustration. And both will also prevent animals from actually having certain experiences that from a human perspective may be interpreted as positive – in particular, experiences of sexual activity and looking after offspring. It is difficult to know how to weigh these positive and negative experiences. It might be argued that humans tend to focus too much on certain “peak” experiences – such as bonding with young – and ignore the countless pains and frustrations associated with frustrated sexual desire, pregnancy (in the case of females), and the rearing of offspring (cf. Benatar 2006). It may be that in terms of subjective experience, aggregate welfare is better for castrated than intact animals.² If, on the other hand, aggregate welfare is better for intact animals, since GnRH treatments are generally reversible in terms of their effects on fertility, and spaying and castration are not, GnRH treatments may have an edge, in at least allowing for the possibility of these positive experiences in the future.

In more perfectionist terms, the use of GnRH treatments and spay/neuter will affect animals’ behavioural repertoire similarly, limiting species-specific expressions of “natural behavior” related to procreation and the nurturing of offspring. And even if we are uncertain whether mating/parenting are positive experiences for animals, whatever animals feel about it, they are clearly natural behaviors. So, both methods look troubling on this account of welfare, although the potential reversibility of GnRH treatments may again give this method a slight advantage.

Some animal rights theorists have additional ethical objections to spaying and neutering. These objections relate to a claim that animals have a right to sexuality or a right not to be coercively sterilized (see, for instance, Donaldson & Kymlicka 2014). Not all animal rights theorists take this view, however; for instance Cochrane (2012) argues that animals do not have a right to reproduce. Another right that could be at stake is a right not to be harmed. Boonin (2003) for instance argues that spaying/neutering an animal imposes non-trivial harms on it without benefiting it, and that this violates an animal’s rights. The only justification for violating this right, according to Boonin, would be if failing to spay/neuter would lead to the birth of many miserable offspring. But this wouldn’t apply to working horses or many companion dogs, since they are not free-ranging, or used for breeding. However, if the alternative to castration is confinement and social isolation, which is likely for stallions at least, castration may still, even from a rights view, be considered the lesser evil; and the use of pharmacological alternatives may be preferred to castration. Donaldson and Kymlicka (2011, 147), for instance, regard “birth control vaccines” as at least relatively non-invasive ways of controlling populations of domesticated animals, even within an animal rights framework that rejects coercive sterilization. Like horses and dogs, farmed pigs also are not kept for reproduction, but due to the circumstances in which they live, it may be the case that each pig has an interest in all (other) male pigs being castrated, in order to limit mounting and aggression. Again, the use of GNRH may be a lesser evil, even from a rights view.

Spaying and neutering may also be regarded as violating animals’ rights on the grounds that animals, like humans, have a right to *bodily integrity*. Although bodily integrity is difficult to define, removal of parts of

² We are grateful to an anonymous referee for suggesting this way of viewing the case.

the body would almost certainly count as a violation. On this view, parts of an animal's body should only be removed if doing so is of significant and direct benefit to the animal itself (for instance, removing a cancerous leg) and one might plausibly think that the animal would give consent to it. From this perspective, GnRH vaccine does not violate rights, while spay/neuter does; so GnRH vaccine looks clearly ethically preferable. However, other accounts of bodily integrity include having "opportunities for sexual satisfaction and for choice in matters of reproduction". (Nussbaum 1999, 41) On this basis, GnRH treatment, as a form of coercive sterilization, like surgical sterilization, would violate the right to bodily integrity; but since it does not *also* require the removal of body parts, and may be temporary, GnRH vaccine still looks less problematic than surgical sterilization.

So, taking these concerns together, where there's an ethical difference between the two techniques, the use of GnRH treatment looks preferable on the grounds of animals' welfare and also, on some views, animals' rights. However, this conclusion would not necessarily apply to free-ranging animals (such as free roaming dogs) where permanent sterilization, more than behavioral control, is of primary significance (and could be justified on welfare-only grounds at least). But in the case of some confined domestic animal species, there's stronger ethical justification for the use of GnRH treatments than for spaying and neutering animals.

4.2 Should we use Pharmacological Fertility Control, or Cull "Surplus" Animals?

Where the primary purpose of fertility control is behavioral, culling is not an alternative. The goal of behavioral fertility interventions is to better manage the animals we want to keep, not to dispose of them. So, culling is only normally considered in the case of unowned free-roaming and wild animals. Here we'll focus on white-tailed deer as a realistic case, since a GnRH vaccine is currently approved for female white-tailed deer.

The main direct effect of GnRH vaccines on white-tailed deer subjective welfare is likely to be the negative experience of stress at capture and application. As in the case of domestic animals, another concern is foregoing plausibly positive experiences of sexual behavior and caring for offspring – though fertility control may also mean that some female deer, at least, avoid other, potentially worse experiences, given how much can go wrong in the process of pregnancy and birth in the wild, and the resources female animals expend on reproduction. So here a lot will hinge on how much sexual behaviour and the ability to care for offspring matter to white tailed deer. From a more perfectionist perspective on welfare, GnRH vaccines prevent deer from carrying out species-specific natural sexual and reproductive behavior – and there may be heightened concern about the loss of natural behaviors in wild animals, in contrast to domesticated ones. As with domesticated animals, the use of GnRH vaccines also raises concerns about reproductive rights or rights not to be harmed. In deer, unlike some of the domesticated cases (such as mares), ideally the effects of the vaccine would be permanent, since that would avoid the need for further captures and applications. This means that any advantages from reversibility in terms of reproductive rights would not apply in wild populations.

So, now let's compare the use of GnRH vaccines with culling deer, either by sports hunters or by sharpshooters, as a strategy for dealing with perceived deer over-population (and, for the present, let's assume that these are alternative, not complementary strategies). In a culling system, deer can exhibit a full range of natural behaviors in terms of sexuality and reproduction, and will (let's suppose) enjoy the positive

experiences these provide. In this sense, culling looks less ethically troublesome than the use of fertility control.

But hunting itself has effects on deer welfare. Both GnRH vaccines and hunting require some kind of stalking – so both may equally create a deer “ecology of fear” (though an “ecology of fear” may be seen as a normal condition for deer living in a natural environment with numerous predators). But if hunted deer are often injured rather than killed, or are not killed cleanly and quickly, then hunting can have extremely negative subjective consequences. On the other hand, if deer are killed quickly and cleanly, as they would typically be in places where deer management is undertaken by professional sharpshooters, their deaths could be virtually painless. However, in many places control of deer population is left to recreational hunters. There’s little evidence available to help in judging how well these hunters do; one study estimated that 4% of adult males in a wholly bow-hunted deer population died from archery-related wounds every year and were not recovered (Ditchkoff et al. 1998). A British study found that 7% of deer shot were not killed outright (Aebischer, Wheatley & Rose 2014). For deer that are wounded but not killed, pharmacological fertility control, rather than hunting, looks subjectively preferable (though the deer undergoing fertility control may not be the same deer as the ones hunted, as the preference is for hunting bucks, while GnRH vaccines are only permitted for use with female deer). On the other hand, wild deer do not usually have long lives anyway, frequently succumbing to disease and automobile accidents. These may be comparatively much worse ends than sport hunting or sharp-shooting. However, on many ethical views, the short lives and unpleasant ends of deer in the wild are not relevant to judgments about how *humans* should behave; a distinction should be made on these views between what humans as moral agents *do*, and what *just happens* in wild nature.

This raises additional ethical questions that we can only touch on here. The use of pharmacological fertility control means that fewer deer are born than would otherwise live, but that they are on average likely to live longer lives, because they are not hunted. Hunting, on the other hand, means that more individuals are born, but that many deer’s lives are (likely to be) shorter. From many consequentialist perspectives – that is, perspectives that focus exclusively on the optimal balance of good and bad outcomes – provided there’s a similar amount of good deer experience in the world, there’s no significant ethical difference between these alternatives. However, for non-consequentialist approaches, in particular animal rights views with a strong focus on negative rights, such as the right not to be killed, this will not be acceptable. While it’s impossible to violate the rights of a being that never comes into existence, hunting (according to these views) violates the most basic rights of existing individuals in a way that their natural, even if painful, deaths at a later time would not. So from these rights perspectives, if one accepted the premise that deer numbers must be reduced, fertility control would be significantly ethically superior to hunting, even if deer generally suffered much worse wild deaths. Other forms of non-consequentialism might take a different approach, however. Varner (2011, 866-869) has developed a version of Regan’s (1983) rights view on which, since wild animals are harmed comparably by death, whether from culling or from nature taking its course, hunting could be justified as a way of minimizing deaths. And theoretically, it would be possible for a rights theorist who took wild animals’ *positive* rights to assistance seriously, to argue that hunting may be justified if it protected many positive rights by violating only a few negative rights. From both these perspectives, though, fertility control still seems preferable.

There’s a lot we don’t yet know about the effects of GnRH vaccines on free-roaming wild deer, particularly in terms of their impacts on deer social structures, and further research on this is needed. Provisionally, though, from a perspective that focuses on aggregate deer welfare, it’s currently unclear whether a GnRH vaccine is to be preferred to culling (and will in part depend on how the culling is carried out). However,

even from rights perspectives that accept animals' reproductive rights, violating these rights is ethically preferable to violating deers' rights to life. But ultimately, a rights theorist might reject both of these approaches in favor of a "do nothing" approach (see below).

4.3 – Should we use Pharmacological Fertility Control, or Keep Sexes Separate?

One possible alternative to pharmacological fertility control would be to keep the sexes separate. This is a possible solution in the case of dogs, where the behaviour of intact male dogs is strongly affected by bitches in heat; if bitches are kept out of smelling distance of male dogs, behavior should be manageable. However, sex-separation has limited application in two of the cases we have considered – male horses and male pigs. The problem of sexual aggression exists even if females are not present, and for male pigs, boar taint will develop in the absence of females. And – while it is less disruptive – oestrus behavior in mares also occurs without males. Separation of the sexes, then, does not help in some of the cases where the reason for fertility control is sexual behavior, rather than unwanted reproduction.

Further, the primary concern about unwanted reproduction occurs in unowned free-roaming and wild animals, where sex separation is not practical (they would no longer be free-roaming)! This limits still further cases where sex separation would actually be useful: primarily in domesticated animals under human management, where the persistence of sexual behavior can be tolerated.

Even so, ethical questions can be raised. Some of the animals concerned are likely to experience sexual frustration, avoided by the use of GnRH vaccines; and isolation from conspecifics may, for example in the case of stallions, be a welfare issue in its own right. There would still be no natural behaviors such as birth or parenting. And, rights theorists such as Donaldson and Kymlicka (2011) argue, keeping the sexes separate still denies animals their rights to social association and interaction, although they suggest sex separation might be acceptable if it is only temporary. So, the separation of the sexes doesn't obviously seem to be better than pharmacological fertility control, and has a narrow range of possible applications. But we will return to sex separation below, when we consider "do-nothing" approaches.

4.4 – Should we use Pharmacological Fertility Control, or Sex Sorting?

A more extreme version of sex-separation is sex sorting: using biotechnology in order to ensure that, except for stud animals, only females come into existence. Achieving this is currently only of general interest in the agricultural sector. It isn't practical for wild or feral animals (though current work on gene drives in some pest species is trying to produce only males) and in the case of companion animals or horses, there's general demand for animals of both sexes. However, in the chicken industry, sex sorting of eggs to end mass culling of one day old male layer chicks is soon likely to become industry standard. Semen sorting alongside artificial insemination to produce female-only offspring is currently also used in dairy cattle production, thus avoiding the culling of some breeds of newborn bull calves due to their low value for beef production. This may become an alternative to pharmacological fertility control where the concern is surplus males, or male but not female aggression – that is, where being a male is not intrinsically useful.

Obviously, sex sorting could have significant welfare benefits – as when preventing male chicks from coming into existence (although this is not an alternative to the use of pharmacological fertility control). While not commercially viable at present, sex sorting could enable production of only female pigs, thereby avoiding both boar taint and aggressive sexual behavior, with the welfare benefits of bypassing castration or GnRH vaccines. However, from a rights perspective this benefit may seem so minor as to be not worth having: which leads to our final comparison.

4.5 – Should we use Pharmacological Fertility Control, or Do Nothing?

One alternative possibility is just to do nothing about fertility control: no drugs, no castration or spaying, no sex separation, no sex sorting. Animals could just be free to express natural sexual behavior, mating, and caring for offspring, and enjoy (or not) those experiences, just as wild animals living outside the realm of human interventions currently do.

The difficulty here, of course, is that the animals we are discussing are either created by human societies or living tightly entwined with them. A laissez-faire fertility policy would make living with the animals in the cases we've considered much more difficult, if indeed it would be possible at all. And even with fairly radical changes in the ways humans live alongside animals, there would be massive problems with respect to animal welfare from huge animal populations, unless at least sex-separation was permitted, which may itself give rise to significant welfare issues.

Many people already live with entire male and female dogs. But few live with an entire male and female dog without any sex separation. Without sex separation, there would be an unmanageable explosion in puppies, with inevitably poor quality of life for many of them. It is possible to keep male pigs entire, but this would mean slaughtering them when they are younger. In the case of horses, mares are currently kept without any fertility control – but again only with sex separation from stallions. Managing stallions without castration or off-label use of vaccinations against GnRH presents real human welfare issues, and also animal welfare issues relating to fights between stallions. In the case of deer, there could also be a “do-nothing” policy, but this would lead to even denser deer populations in suburban areas, an increasing number of vehicle/deer accidents, and the potential for overused ecosystems, malnutrition in deer populations, and other human/deer conflicts.

How to think about “do nothing” policies in these cases seems to turn on two factors: first, how far to focus on an “ideal” situation, in contrast to taking a reformist approach that starts from the non-ideal existing state of affairs, and second, whether one adopts a broadly consequentialist or non-consequentialist approach to ethical problems.

So, for instance, a consequentialist whose goal was to bring about the best animal welfare possible (whether in terms of subjective experience or natural behavior) might think it ideal if no pigs were kept intensively (or at all); and that next best, in the USA at least, would be to reduce slaughter age and weight to avoid the need for castration or fertility control. However, ending intensive pig keeping in the US any time soon is extremely implausible, and reducing slaughter weight and age is not very likely in any foreseeable future; while slaughter at a younger age may result in the need to breed more pigs, unless combined with achieving a decrease in demand for pork. Focusing on a more feasible, immediate range of options in a non-ideal

world, to improve welfare, this practical consequentialist might campaign for ending the standard practice of castration, and introducing GnRH vaccination for male pigs instead, as a relatively achievable way of significantly reducing animal suffering.

A rights theorist might argue strongly for an abolitionist approach – that keeping pigs for food is in principle unacceptable – not just intensively, but even when pigs have good welfare. For many rights theorists, this is all there is to say: small changes in welfare don't change the basic rights violation, and welfare reforms may obscure it, taking us further away from the ideal by giving the appearance of improvement. But some rights theorists might take a less stark view, accepting the possibility of discussion about what constitutes a lesser evil, perhaps in terms of a so-called “non-ideal” approach. Such a rights theorist may, to some extent, accept consequentialist considerations – that pig production should not take place, but since it is for now inevitable, pigs should be kept and cared for in a way that minimizes suffering and where their bodily integrity is not violated. And therefore, pharmacological means of fertility control may be viewed as the lesser evil. Similar arguments may be made in the case both of male dogs and horses. Even if, as some rights theorists (such as Francione & Charlton, 2016) argue, we should not keep animals as companions or as workers, given that those practices will continue to exist, and abolition seems far away, GnRH vaccines can be considered morally preferable to the pain and loss of bodily integrity from castration. Again, though, this may lead to concerns that accepting the lesser evil indirectly serves to legitimate and reinforce a far from ideal status quo.

White-tailed deer raise a somewhat different set of issues, because they are not owned and domesticated. Even though the white-tailed deer populations under consideration have been heavily influenced by human activities, including in some cases having descended from re-introduced populations, they are not deliberately bred or kept by humans for particular purposes. And in this case – since humans don't want to use deer for anything (other than hunting, which is part of the point) – the standard existing alternative to GnRH vaccine is not castration or spaying, but killing.

For a practical welfare-aggregating consequentialist, what matters is achieving the best welfare outcome within reach. As we have suggested, it is not entirely clear yet what that is, but if GnRH vaccines could be administered by dart (avoiding the need for capture) and be a “one-shot-sterilizes-permanently” treatment, it is likely that this would produce better deer welfare than either culling or doing nothing.

A rights theorist, though, is likely to take doing nothing as the default option. We have duties not to violate animals' rights (so, we have duties not to kill them, and, arguably, duties not to coercively sterilize them, although the latter view isn't universally held). A rights theorist would likely argue, in the case of deer, that it is possible to live alongside them without hunting them and without applying fertility control. But this will mean significantly changing aspects of the ways people live – to reduce human/deer conflicts and road traffic accidents. Donaldson and Kymlicka (2011) argue that in cases of this kind, if we have good reason not to want high populations of “liminal” animals in human spaces, we may use physical barriers and other disincentives to exclude them, and set up our societies so as not to attract them – abandoning luscious lawns and flower arrays, for instance. Where animals such as white-tailed deer live alongside our communities, Donaldson and Kymlicka argue, it is not reasonable to expect the animals to take all the risks and make all the sacrifices – especially where humans have colonized their territories in the first place.

6 – Conclusion

This paper has been able to do little more than to sketch some of the ethical issues raised by the use of GnRH treatments with respect to impacts on the affected animals. We haven't been able to discuss broader questions about loss of "wildness" from using fertility treatments on wild animals in any detail, nor considered in depth what some of the changes suggested here mean for human beings. We hope to have shown that whether non-surgical, pharmacological fertility control is the ethically preferable choice for the animals concerned depends both on the details of the particular case, the likely alternatives, and the theoretical perspective taken. Where the ethical problem is pressing, as in male pigs, and the realistic alternative is castration, then GnRH looks like the best immediate solution. Where the problem is little more than inconvenience, as with achieving docile mares for horse shows, then do-nothing with separation from stallions may be better. In the case of deer, GnRH may be ethically preferable to culling in terms of animal welfare, especially if it could be administered by dart. While saying this, it is also possible, from both consequentialist and rights perspectives, to argue that these are only stopgaps, and that we should reconfigure at least some of the human practices that give rise to the need to control animal sexual behavior and reproduction.

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