**INVITED REVIEW**

**Ethics in animal breeding**

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**Contents** Ethical breeding involves the use of healthy animals true to their species in behaviour and physical appearance, and when applicable, showing a sustainable performance. The concerns for the species/breed are essential parts of the breeding goals, including preservation of genetic resources within the species/breed, and the health and welfare of the individual animal. Ethical and welfare considerations were often not prioritized in developing new breeds of production or companion animals. As a result, animal breeding practices are increasingly becoming part of the debate on animal welfare. In companion animals, breeding for curiosity or “cuteness” may be a goal in itself, although dogs are also bred for utility. In production animals, breeding focus is on performance, i.e. quantitative entities and financial income, rather than physical appearance. For instance, dairy cows are bred to be larger and to have higher milk yields, sows and ewes to produce more offspring, and horses are designed for riding, racing and companionship. Overbreeding in relation to current demand of horses, cats and dogs raises welfare issues due to abandonment or killing of horses and millions of cats and dogs every year. There is variable regulation of health requirements for breeding animals in different countries of the world. In many countries, consumers are becoming increasingly aware of animal welfare issues such as negative effects of certain production traits in farm animals, leading to decreased demand for their meat at a time where increased food production is becoming crucial. Amidst these dilemmas are the veterinarians. This paper deals with issues connected to traditional breeding as well as some of the breeding technologies, and includes food safety, ethics and animal welfare.

**Keywords: Animal breeding, breeding goals, animal welfare, companion animals, ethics, production animals**

**1 INTRODUCTION**

Ethics is a set of moral principles that governs a person’s behaviour or the conducting of an activity. The moral code of a person or a population is culturally defined, and may depend on religion, politics or nationality (Crony and Millman, 2007). One may argue that there is such a phenomenon as core human values or ethics, which may be common to all humans irrespective of cultural background, with most individuals being strongly against hurting or mistreating other humans, especially children. Similar core values also exist in our relationship to animals, with most humans displaying strong empathy with animals, especially with those species, to which they are culturally and emotionally attached (Merz-Perez et al. 2001). This equates to treating animals we own well, so they can serve humans better (utilitarian principles); treating them well because we have been given responsibility for them (“parent” principle); or treating animals well because animals have a value of their own (intrinsic value) and therefore have certain rights (right based). Hence, ethics of animal husbandry including animal breeding may be about treating animals so that the animals do not suffer, treating them well in order to increase our benefits from keeping them, or because they have a right to have a good life. Irrespectively, all these approaches claim that we treat animals in such a way that their health and welfare are not compromised during their lifetime. Animal welfare is defined by the World Organization for Animal Health (OIE) as “how an animal is coping with the conditions in which it lives.”

A good definition of breeding *per se* is not easy to find, although most people will have a general understanding of the meaning of the term animal breeding as the deliberate sexual reproduction of animals. Definitions in dictionaries differ but none includes or elaborates aspects of strategic breeding: i.e. the activity of keeping and caring for animals in order to produce more animals of a particular kind or with particular attributes. Strategic breeding involves the specific selection of parent animals and sometimes includes assisted breeding (Merriam-Webster;  [Cambridge English Dictionary](%5C%5C%5C%5Cnmbu.no%5C%5Cmy%5C%5Chome%5C%5CTEKST%5C%5CTEKST%5C%5CMANUS%5C%5CEVSSAR%20Wien%202017%5C%5CLast%20review%5C%5C%20Cambridge%20English%20Dictionary) and Oxford Dictionaries).

From a veterinary perspective, breeding of companion animals is mainly performed by breeders, who produce a limited number of offspring. In livestock and fish, however, breeding can be considered being part of an extensive industry, aiming to have a high number of offspring output. Task of the veterinary community is to address limitations and animal welfare issues in both types of breeding enterprise.

When combining the two terms “ethics” and “animal breeding”, the meaning is deliberate production of animal offspring, which involves the conscientious consideration of whether it is morally correct or acceptable to produce the intended offspring. Hence, ethical breeding needs to involve “*the use of healthy animals true to their species in behaviour and looks, and when applicable, showing a sustainable performance” (*Olsson et al. 2006].

Animal welfare is closely associated with animal breeding, since in many ways we use animals to fulfil the human demands for companionship, beauty, entertainment, research, utility, protection, food, and financial income. Humans have to make ethical considerations when they define breeding goals based on a balance between our demands and the animals’ requirements. Any domestication affects animal behavior, which may vary among the different species. Adaptation to a human environment will occur to a varying degree.

Animal breeders often select their breeding subjects based on specific attributes, aiming to reach individually defined excellence in production traits, physical appearance or performance, regardless whether they breed alpacas, hens, cats or cows. The reasons for breeding animals are numerous and differ depending on the type of animals. Often financial aspects play an important role. Unfortunately, physical and functional soundness is not always of high priority when they design new types, for example in a new cat breed or a high yielding dairy cow.As a result, animal breeding practices and the outcomes of breeding have become part of the debate dealing with issues of animal welfare and the responsibility of breeders and veterinarians.

 Breeding is normally performed by natural service in nature, in companion animals and sometimes in livestock. However, assisted breeding techniques, such as artificial insemination, in vitro fertilization, and embryo transfer, are generally accepted by the public and have gained an important role in the last decades in many species, especially in cattle, in Europe, the US and many other countries. Assisted breeding techniques may also involve manipulation of gametes *ex vivo.*  Interventions such as intracytoplasmic sperm injection (ICSI), embryo transfer or cloning by nuclear transfer may raise ethical concerns.

In the following review paper, some of the ethical issues of breeding in companion and production animals (including fish) will be presented. Society’s expectations will be discussed, and the role of the veterinarian in breeding ethics will be highlighted.

**2. BREEDING OF SPORTS-AND COMPANION ANIMALS: DOGS, CATS AND HORSES**

When we want to buy a canine companion, we can choose from 350 to 400 different dog breeds. Often, in companion animals, breeding for curiosity or for “cuteness” may be a goal of some breeders in itself. “Overtyping” is the deliberate breeding of particular attributes that usually bear a negative impact on health and welfare, and which in the past often led to a significant narrowing of the genetic variation of a population. Positive selection pressure is generally put on those individuals that show the most extreme expression of desired traits, while those individuals that do not possess these traits are discarded as breeding animals, leading to a reduction in genetic diversity (Fredholm, 2017). Most modern dog breeds have challenges concerning inherited defects and diseases, since almost 700 hereditary diseases are registered in dogs according to Online Mendelian Inheritance in Animals (**OMIA**). In this catalogue/compendium of inherited disorders, information on single-locus traits and genes in 239 animal species are collected.

The Labrador has been the most popular dog in the UK for almost three decades, but according to The Kennel Club (UK) by the end of 2018 its top place could be challenged by the brachycephalic French Bulldog. Kennel Club figures reveal that registrations for this breed rose by 47% from 14,607 in year 2007 to 21,470 in 2015/2016. The rapid rise of the popularity of the French Bulldog seems to be based on a combination of celebrity impact, commercials and exposure on social media. As reported by the BBC correspondent Claire Marshall in 2017, “*They've become a sort of fad - but veterinary experts say that the craze for these 'designer' dogs is helping to create dogs with painful deformities*”. The major problem is that many brachycephalic dogs have difficulties in breathing, and panting to cool down in high ambient temperatures is difficult. This is linked to developing upper respiratory tract disorders, the brachycephalic obstructive airway syndrome (BOAS), because of their short skulls, extreme flat short noses and narrow lanynges, (Koch et al. 2003; O'Neill et al. 2015). The same problem occurs in brachycephalic cat breeds, e.g. Persian cats (Schlueter et al. 2009).

**DOGS**

**Conventional breeding**

Conventional breeding or natural breeding is for many dog breeders and the public the most preferable way to produce offspring, since it allows normal sexual behaviour and interaction between males and females. Sexual behaviour in such a context may elicit positive emotions, which is an important aspect of animal welfare (Mellor, 2015). However, if breeders force mating or use a male much larger or smaller than the female, this may not be in the best interest of the bitch, it may impede good socialization of the animals, and may interfere with natural behaviours which consecutively may hamper a successful natural mating. This may lead to the wish for assisted breeding, i.e. artificial insemination.

The welfare aspect of a bitch needing to experience pregnancy, which is often argued by owners of family dogs, is not scientifically proven. However, in the discussion of the significant effect of positive emotions on animals welfare, the effect of experiencing maternal care cannot be entirely disregarded (Mellor, 2015).

Some breeds have developed a predisposition for dystocia or other periparturient diseases. Typically, this concerns the brachycephalic breeds and breeds, such as the Scottish Terrier or Collie, where foetal heads are relatively wide (brachycephalic breeds) or long (Scottish Terrier, Collie), and the pelvis of the dam has a small (brachycephalic) or triangular diameter (Scottish terrier). These breeds have an increased risk of dystocia and consequently assisted delivery or Caesarean section (Bergstrom et al. 2006; O'Neill et al. 2017). The study by O’Neill et al. confirmed the welfare concerns related to brachycephalic obstructive airway syndrome (BOAS) as well as other health problems described earlier to be common in these breeds (Koch et al. 2003; Pratschke, 2015), and highlighted the need for breeders to address these issues when selecting dogs for breeding.

**Fertility and overbreeding**

Except for working dogs, i. e. sniffer dogs, police and military guard dogs, hunting dogs and dogs bred for human assistance (guide dogs), the vast majority of domestic dogs are kept as companion animals. In working dogs, where high performance in working tasks is essential, assortative breeding is often used, a selection strategy based on animal performance or an expectation of performance (Bourdon, 2000).

The market of breeding dogs is regulated by supply and demand, and is influenced by popularity as well as the wish and request for companion or working dogs. Two large data surveys conducted on feline and canine fertility were recently published, showing that fertility in cats and dogs is high in terms of pregnancy rate, birth rate, litter sizes and low abortion and stillbirth rates, but breed variations are significant (Chastant Maillard et al. 2016; Fournier et al. 2017). High fertility and high demand make dog- and sometimes cat- breeding very profitable in terms of high puppy prices for popular breeds. However, overproduction of undesired animals may lead to crowded animal shelters and euthanasia or killing of millions of cats and dogs every year due to loss of interest or for economic reasons. Consequently, regulations on overbreeding and selling by third parties via so called “puppy mills” and illegal import have now been introduced in some countries, such as the United Kingdom, the USA and Australia*,* although the business of puppy mills is yet not under control. The rapid growth of the internet and social media offering direct contact with the buyers may have worsened the situation. The lack of regulation of the trade of pedigree dogs, including specific requirements for health certificates, is of increasing concern. Therefore, international directives should be introduced to both to legitimate responsible breeders and to address the concerns of the public.

**Artificial and assisted breeding**

Artificial insemination (AI) is the procedure of instrumentally inserting semen collected from a male into the female’s reproductive tract. In dogs, the use of AI has increased steadily and the preparation of fresh, fresh chilled and frozen-thawed semen increasingly supports breeding and sharing genes between countries and continents (Payan-Carreira R et al. 2011).) The use of AI to overcome physical or mental defects or lack of libido in dogs that preclude natural sexual behaviour or mating may not be acceptable if the defect is considered hereditary. However, for most of the conditions that prevent natural mating scientific data on the heritability is scarce.

**Cloning (somatic cell nuclear transfer)**

The cloning of dogs was first reported in in 2005 by Lee et al. and is reviewed in the current issue of this journal entitled “Dog cloning – no longer science fiction” by B. Lee and coworkers (2018). Although the pregnancy rate and number of live born puppies is below that occurring after natural service and AI, a 50% full term pregnancy rate and 5-6% survival rate to term of cloned embryos was reported by Jeong et al. 2016. The health issues of cloned offspring at birth described in some of the larger domestic animal species have yet not been reported in dogs so far. However, more research by more research groups is warranted. Cloning of dogs was initially developed to create individuals that could be used as medical research models, since dogs and humans have many genes involved in disease development in common, and for special tasks, such as rescue dogs and sniffer dogs. The ethical aspect of dog cloning for these purposes has so far not been questioned very much by the scientific community nor the public. In addition, cloning of individual pets has so far not become a much sought for service due to the high costs. In the future, more debates concerning the ethics of animal cloning may arise.

When conducting an ethical analysis on each of the artificial breeding techniques in connection with the welfare of dogs, England and Millar (2008) introduced a modified ethical matrix. This may be used to assess the concept of wellbeing, autonomy and fairness of a particular action such as breeding, AI, or other Assisted Reproduction Techniques (ARTs) or treatments to the corresponding interest group. This matrix is useful to assess the ethical aspects of a particular intervention and is applicable irrespective of species (Fig 1).

**CATS**

Cats have traditionally been a natural companion animal in rural areas where they are used to control rodent numbers. Compared to dogs, breeding cats for specific traits is less common although cats are also used as a model animal in biomedical research. The Researchers at the University of Texas produced the first feline clone named “Copy Cat” (Shin et al. 2002); although in common with other species, the efficiency was as low. There is no documentation in the scientific literature or public media that the welfare of cloned cats (and dogs), neither the donors nor recipients, is compromised in a way it is in livestock, such as cattle and pigs. However, the principle of cloning and the unforeseen future consequences of breeding by cloning in any species led to a legal ban on somatic cell nuclear transfer cloning in 1997 in Norway, whereas in other countries such as The USA, The UK and South Korea, it is legal in animals, but not in humans.

Nowadays, cats are valued pet animals in both urban and rural areas, and they have a high fertility rate. A variety of domestic cat breeds and domestic and wild hybrids have been bred, of which not all are well adapted to life with humans. Roger Tabor (UK), biologist and author of "The Rise of the Cats" (Tabor, 1995) stated: “*In cat breeds, physical mutations that were previously allowed to perish, are now being developed merely for the sake of difference. Not all are harmful, but some are achieved at considerable cost to the cat*." One example of a controversial cat type are twisty cats, also known as squittens or kangaroo cats (Leary, 2016). These cats are born with short forelegs that are the result of conditions such as radial hypoplasia, radial aplasia, radial agenesis or foreleg micromelia. Due to their short forelegs, they often sit in an upright posture similar to a kangaroo or squirrel(Hartwell, 2012). Another curiosity is the nude cat, which has no body hair except whiskers. These cats need special care due to their lack of fur in cold climates and protection against the sun in warmer climates. Persian cats are in many ways similar to brachycephalic dogs with their large round eyes, flat faces and short noses, making them susceptible to traumatic keratitis, dyspnea and dystocia. Hence, many of the designed cat breeds will need special care and medical attention.

**HORSES**

In Western countries, the focus in horse breeding is usually not on meat quality, but rather on sports- or working performance, e.g. racing, pulling, riding or herding. As other companion animals, horses are subjected toselective breeding for traits that humans consider desirable, such as extreme sizes. In some regards, the breeding for originality or curiosity also plays a role in horses, as it does in smaller companion animals.

**Breeding exceeds demand**

Overbreeding in relation to demand creates welfare issues of horse abandonment and/or killing for example in the UK. Unwanted horses are often rehomed, but frequently also left to themselves, or are euthanased, because of the high cost of keeping, feeding and caring for them, sometimes due to injuries or old age, or because of a change in the life status of the owner. Horsemeat is considered acceptable for human consumption in some countries and, therefore, horses are slaughtered in abattoirs. In countries, such as the UK and the USA, where horses are considered not suitable for human consumption, a system of slaughtering and processing for other use, e.g. in dog food, may exist (Montpoli ,2013). Abandonment and neglect, as a result of overbreeding, has been identified by various equine charities as a major welfare issue ( e.g. World Horse Welfare, 2013). At the end of 2007, a number of 11,476 horses were in the care of member charities of the National Equine Welfare Council in the United Kingdom.Similarly to dogs and cats, high demand makes horse breeding profitable, but overproduction leads to the slaughter of thousands of horses every year.

**Breeding practices**

According to Campbell & Sandoe (2015) welfare problems related to breeding, for example by natural mating after long road or air transport, or by the application of artificial reproduction techniques (ARTs), have been given little attention in the academic literature. Potential welfare issues are associated with breeding, regardless whether the technique used is ‘natural’ or ‘artificial’. This relates to reasons, such as selecting inappropriate breeding animals, excessive frequency of breeding, and health issues related to parturition.

**Artificial insemination and embryo transfer**

Transport of breeding animals for long distances is common in horse breeding. Artificial or assisted reproductive techniques, such as AI and oocyte retrieval, may help to overcome some of the disadvantages of live animal transport, and also to prevent the spread of equine contagious diseases transmitted by direct contact. Campbell and [Sandoe](https://www.ncbi.nlm.nih.gov/pubmed/?term=Sand%26%23x000f8%3Be%20P%5BAuthor%5D&cauthor=true&cauthor_uid=25908746) (2015), nevertheless, point to research indicating that oocyte retrieval by ovum pickup may cause discomfort to the mare, highlighting possible welfare concerns of ART in horses .

**Cloning**

In equine reproduction, production of embryos using somatic cells as the source of nuclear transfer is nowadays both a research tool and a clinical service (Hinrichs, 2012). Although the number of cloned foals was small in 2012 (estimated at 100 to 200 worldwide; Hinrichs, 2012), Johnson et al. (2010) reported that only 26% of cloned embryos resulted in the birth of a live foal.

Possibly because there is not the same public concern about the possible negative effects on human health when consuming food products derived from cloned animals, such as cattle and pigs (EFSA, 2012), data about the health and welfare of equine clones is scarce. The hormonal treatment for superovulation and ovum pickup in embryonic cloning may possibly be painful to donor mares as suggested by Campbell and [Sandoe](https://www.ncbi.nlm.nih.gov/pubmed/?term=Sand%26%23x000f8%3Be%20P%5BAuthor%5D&cauthor=true&cauthor_uid=25908746) (2015) and Campbell (2018). This points to possible welfare concerns and ethical considerations in the equine embryo technology industry.

**3 BREEDING OF PRODUCTION ANIMALS**

In production animals, the breeding focus is on production performance, i.e. quantitative entities, yield, (meat or milk, eggs or fleece) rather than physical appearance*.* Some cattle breeds are bred to reach very high production levels (Lucy, 2016). As an example, one Wisconsin Holstein cow set a United States of America national milk annual production record of 35,000 kg of milk, whereas the actual production average for all USA Holstein herds in 2014 was 11,318kg of milk. A yearly increase of 12 % in annual milk yield rate per cow has been recorded the last ten years (2008 – 2017) according to The USA Department of Agriculture National Agricultural Statistics Service (2018). Consumers are becoming increasingly aware of the welfare issues of modern breeding and keeping practices. These concerns have led to a decrease in demand for conventional farm products and an increase in demand for organic food products in some countries.

**CATTLE**

**Dairy cattle**

High yielding cows have been bred because of their large genetic potential for increased milk production and current herd management strategies focus on “high income over feed costs” (IOFC). This development led to higher requirements in terms of food quality and fertility management. For example, impaired ovulation and silent oestrus led to the increased use of hormonal treatments. One of the suggested regimens for programmed ovulation is the Double Ovsynch protocol, which includes as many as four GnRH and two PGF2a injections per female to induce ovulation that can be used for timed AI (Souz et al. 2008). From an animal welfare point of view this may not be acceptable, and there is a risk of reducing the ability to ovulate naturally since ability of spontaneous ovulation is not part of a deliberate genetic selection anymore (Lucy, 2016). The concern is that timed AI programs that are commonly used in the United States and other parts of the world may mask infertility by enabling otherwise infertile cows (non-cyclers, etc.) to become pregnant. These infertile cows may have a high daughter pregnancy rate (**DPR)** because they received a timed AI and become pregnant early post-partum, sometimes even with sexed semen. In consequence, the reproductive system of the offspring may not function independently of external intervention (Lucy, 2016). Although pregnancy rates have increased in Holsteins (Norman et al. 2009), they are significantly lower than in cattle breeds that produce less milk. E.g. the dual purpose cattle Norwegian Red averages 8000kg per year with a Non Return Rate (NRR) on day 56 of 72% and a calving rate of 65% (. Holstein cows that produce an average of 11 300kg (23000 pounds) of milk annually, (Holstein, USA; The USA Department of Agriculture National Agricultural Statistics Service (2018) show NRR percentages as low as 35%-40% (Fouz et al. 2011). The consequence of strict selection for increased milk production in Holstein dairy cows has been a very noticeable reduction in reproductive performance ([Berry et al. 201](https://www.sciencedirect.com/science/article/pii/S0022030217311177#bib7)6), and for this reason selection of reproductive efficiency and daughter fertility has been emphasized in Holstein breeding programs since 2010. A consideration of a combination of milk yield and health parameters in the context of breeding is necessary to prevent such unwanted effects on cow health and welfare (Berry, 2017).

**Beef cattle**

Many beef cattle breeds are bred to produce a maximum of daily weight gain. Some breeds have special attributes that make them attractive on the beef market, but some traits are also associated with health problems. The probably most referred to breed in the context of animal welfare issue is probably the Belgian Blue. Its double muscling is due to a mutation of the myostatin gene, which codes for the protein myostatin that inhibits muscle development (Kambaduret al. 1997*).* This mutation also interferes with fat deposition, resulting in very lean meat and high protein value. The meat, therefore, has an extraordinary tenderness and taste, which makes it attractive on the beef market. However, myostatin mutations can affect a number of different body systems, and have a negative impact on the welfare of cattle. The most widely known symptom in Belgian Blues is dystocia and the extraordinarily high rate of caesarean sections due to the large muscle mass on the back end of the calf (West, 1997). Furthermore, problems with deformations of the jaw and over-enlarged tongues, which affect the calf’s ability to suckle and hence its survival, as well as respiratory, heart and reproductive problems, have all been documented in the Belgian Blue breed. The welfare issues related to the mutations has prompted veterinarians to discourage crossing these breeds with other double muscled breeds.

**Artificial and assisted breeding**

**Cloning and genetic engineering**

While cloning and genetic engineering are only briefly dealt with in this review, it is important to note that these new technologies are becoming increasingly prominent in modern assisted breeding procedures in livestock (Hasler, 2014; Perry, 2016).

The procedure of cloning by somatic cell nuclear transfer (SCNT) in most mammals results in pregnancy rates much lower than those obtained in vivo after insemination and from transfer of embryos derived in vitro ([Kruip](https://www.sciencedirect.com/science/article/pii/S0093691X9600338X#!) and [den Daas](https://www.sciencedirect.com/science/article/pii/S0093691X9600338X#!), 1997). Furthermore, in some species a significant proportion of cloned fetuses that survive to term have disorders such as oversized organs, increased or decreased overall growth, respiratory failure and limb malformations. In cattle and other ruminants, these abnormal phenotypes are referred to as the large offspring syndrome (LOS) (Young et al. 1998). Improper development of the placenta may play a major role in fetal abnormalities. It has been suggested that the pathological phenotypes in the placental and fetal development of clones are associated with abnormal reprogramming by the host ooplasm of the donor cell used for nuclear transfer (Humphreys et al. 2001; Rideout et al. 2001; Suzuki et al. 2009). Abnormal offspring in some domestic animal clones entails a cost of cloning to the animal, the species (increased risk of reduced genetic diversity), the breeder, as well as the veterinarian and society that are concerned with the health and welfare of the clones and their offspring (EFSA,2012) .

Several terms describe genetically engineered animals: genetically modified, genetically altered, genetically manipulated, genome edited, transgenic, and biotechnology-derived, amongst others. In the early stages of genetic engineering, the primary technology used was transgenesis, literally meaning the transfer of genetic material from one organism to another (**Waigmann et al. 2012)**. However, with advances in the field, new technologies have emerged which do not necessarily require transgenesis: recent applications allow for the creation of genetically engineered animals via the **gene editing** (CRISPR) insertion or deletion of genes, or the manipulation of genes already present (Ormandy et al. 2011; Sander and Joung, 2013). **CRISPR** (Clustered regularly interspaced short palindromic repeats)was used to produce two Holstein calves without horns in Minnesota USA in 2016 (Akst, 2016). Gene direction can be used to increase disease resistance and other attributes that may be of advantage. However, there is a potential for altering genes that may compromise the intrinsic value of cows, such as insertion of genes from other species, or creating traits that are more beneficial to production profit than to the cows themselves (Eriksson et al. 2018). In these cases, insertion of genes may be considered unethical or controversial, opening up issues relating to animal integrity and/or dignity (Ormandy et al. 2011).

**SWINE**

**Sustainable breeding goals**

Most pigs are bred for meat production, a smaller number are bred either for research purposes or for companion animals (minipig). These three categories of production have their own challenges and have different breeding perspectives and ethical issues.

**Ethical issues in industrial pig breeding**

Litter size in pigs varies between breeds, is regulated by ovulation rate, embryo survival and uterine capacity, and is an important economic factor in swine production. While selection for increased litter size yields more born piglets, large litters are also characterized by a higher risk of intrapartum and postpartum death (Rootwelt et al. 2013) as reduced placental area per piglet leads to lower birthweights. These results may indicate that there is an upper uterine limitation of litter size and that placental area and placental weight influence postpartum survival (Rootwelt et al. 2013). Selection for increasing number of teats in sows may be a way to increase teat availability per piglet, although this may also affect vertebral development (Duijvestejin et al. 2014). Hence, selection for increased little size in maternal pig lines may be limited. Crossing this limit may not be ethical because the number of piglets weaned is compromised due to sibling competition, piglet birthweight differences and uneven growth, which hampers piglet welfare and leads to increased mortality and increased financial losses for the owner (Ocepek et al. 2017). Selection for larger litters should remain within reasonable borders and be accompanied by better surveillance of parturition and low weight piglets, although these measures are costly in high intensity large swine production systems.

**CHICKENS AND HENS**

**Featherless chickens and killing of males**

While featherless broiler chickens are believed to be a more resource-efficient and, according to the breeders, suffer less welfare problems (Olsson et al. 2006), many people have major concerns because the presence of feathers is considered an essential characteristic of birds. While genetic selection is not generally unacceptable, brought to extremes, it may be objectionable because questions arise about the conditions in and about the purpose for which animals are bred. This is also an example that the animals’ original characteristics and dignity may be compromised.

In egg laying stock production nowadays usually all males are sorted out and killed - similar to male dairy goat kids, as well as surplus dairy breed bull calves- due to the costs-outcome imbalance of raising the male animals for meat production (Turner, 2010). In Norway, which has no tradition for consuming goat kid meat, nearly 31 000 surplus newborn male goat kids are killed annually (Roed, 2017). To many people this gender sorting and killing is ethically unacceptable because it implies that these animals are surplus by- products and therefore this practice violates the intrinsic value of animals.

**FISH**

**Environmental concerns**

Compared to land farmed animals the welfare of fish and breeding ethics have not traditionally been an important issue for consumers, producers and legislators. Basically, until recently, fish were not much taken into consideration regarding welfare issues (Huntingford et al. 2006). A number of factors may explain the reasons for the lack of public concern regarding fish welfare, some of them based on ethical views. Fish do not elicit compassion in humans in the same way as other warm-blooded animals do. In addition, unlike mammals, fish do not show vocalization or physical symptoms of pain, and rarely show behavioural reactions that humans can easily interpret. Most importantly, until recently, the general view was that fish could not experience pain in the same way as higher vertebrates. The existence of pain receptors (nociceptors) in fish was only confirmed in 2002 (Sneddon et al. 2003) leading to the recognition of fish as sentient animals. Also, large scale industrialized aquaculture is a relatively recent farming method, and the animal welfare and health challenges of fish farming has only recently come to the attention of the public (Huntingford et al. 2006). Even though the welfare of farmed fish has improved significantly in recent years in many countries with new legislation, a number of welfare issues still exist, including skeletal deformities, cataracts and heart disease, hormone treatments - induced spawning (GnRH), triploidity and transgenic technologies.

One area of public concern has been the development of transgenic fish. While transgenic fish are currently banned in Europe, the first genetically modified salmon (AquAdvantage- salmon developed by [AquaBounty Technologies](https://en.wikipedia.org/wiki/AquaBounty_Technologies)) was put on the food market in Canada in 2015. This genetically engineered Atlantic salmon grows faster due to a growth hormone (GH) gene insert, which functions to increase endogenous GH production. While production of sterile transgenic salmon in land-based tanks in Panama has now been approved by the USDA, major concern still persists over the potential environmental impact of escaped transgenic fish. Due to their larger size and increased aggression, escaped transgenic fish may have a serious impact on wild conspecifics (Upton and Cowan, 2015).

**Triploid salmon**

There is growing interest in the use of triploid fish in aquaculture. There is concern regarding the large size of the farmed stocks relative to wild fish, particularly over potential adverse impacts of escaped farmed salmon through potential interbreeding with wild fish (Green et al. 2012).The production of triploids, which are functionally sterile, would result in two major benefits. Firstly, the use of triploid fish would negate the problem associated with early sexual maturation in aquaculture, and secondly triploids, in being sterile, would mitigate the main environmental concerns of potentially escaped fish (Benfey,2015; Iversen et al. 2016).

**4 DISCUSSION**

**Veterinary involvement**

The primary task of veterinarians is to *protect and monitor* the health and the welfare of animals. As such, veterinarians give professional advice to owners, the society and governmental institutions regarding possible positive and negative effects and welfare issues of treatments, breeding practices and production systems. In that regard, veterinarians have to communicate evidence-based information on potential risks to owners (breeders), media, the animal breeding industry, the Food Safety Authority and other stakeholders such as the general public, animal welfare activists and politicians.

In recent years welfare issues related to animal breeding are increasingly discussed. In 2017, 1500 Norwegian veterinarians signed a petition against breeding brachycephalic breeds (Strand, 2017). Furthermore, during the 2017 FECAVA congress a note was posted that aims at encouraging veterinarians to speak out against unethical breeding practices related to brachycephalic dog breeds (FECAVA, 2017). At the EVSSAR congress 2017 ethics of animal breeding was addressed, and this topic will be continued also in 2018.

In everyday contact with animal owners and breeders, addressing animal welfare and ethical issues may be a difficult task. Some potential dilemmas that veterinarians are facing with regard to breeding are highlighted in Fig. 1. For instance, regarding the statement *Satisfactory income and working conditions* (VW) vets are involved in many aspects of the breeding and production systems and may partially rely financially on the economic success of these systems. However, of course regarding the statement *Professional freedom* (VA) they have the possibility to decline required interventions and should be intolerant towards systems that compromise animal welfare exceedingly. In that regard also the statement *Equitable standards of Practice* (VF) is important because it means fair and impartial attitudes towards all parties.

The dilemmas listed here are applicable to any species, since they also exist when dealing with all production animals (including fish), and animals used in research. All unsound breeding practices should be under scrutiny irrespective of species. As genetically engineered animals are released on the food market, such as Atlantic salmon, special care, biosecurity and management may be required. Veterinarians not only are responsible for health care of these animals, but also contribute to policy discussions related to their health and welfare, including breeding practices. In some instances, veterinarians may have to refrain from profit when owners and breeders need telling about the welfare implications of poor health due to dysfunctional exterior traits and unsound breeding practices. They have to be clear and elaborate when describing the animal’s problem(s) to the owner, to breeders, to organizations such as kennel clubs, farmers’ organizations and governmental institutions, and highlight the ethical considerations surrounding those breeding practices.

**Future perspectives and society**

**So**ciety has to focus more on the welfare implications of current breeding practices. Growing global population is putting increasing pressure on modern agriculture, with objectives designed to meet food security and food safety. In addition, there is increasing emphasis on more sustainable food production, and in meeting high food quality standards. Unfortunately, these increased challenges for agriculture can be counterproductive to the increasing focus on improving animal welfare in production animals. In addition, it is likely that future animal production, both terrestrial animals and fish, will be influenced by climate change. Currently, the economic independence of the wealthier countries allows the inhabitants to share large volumes of food with companion animals that are not producing food, but rather consuming it and competing for the same food source with people from poor countries. The extent to which people will be able to keep family pets as now for a foreseeable future, is not known if food resources relying on animal protein is becoming scarce. However, breeding of peculiarities (designer dogs and cats) and allowing advanced medical treatment of pet animals with poor health most certainly and hopefully, will be challenged. The resulting health problems must be addressed appropriately and effective improvement of the situation will not occur until all stakeholders acknowledge their own responsibility in this process.

**CONFLICT OF INTEREST**

The author has no conflict of interest to declare.

**AUTHOR CONTRIBUTION**

This work was written by Wenche K Farstad

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Fig 1.\* *Reproduced with written persmisssion from the authors*

LEGENDS Fig. 1

The Modtfied Ethical Matrix is using dog as an example, but can be applied to all animals.

From the breeders point of view the decision to breed an individual animal is purpose, why one wants to breed an animal. Then breeding decision must be taken based on risk assesment of compromising the dam’s welfare, the welfare of the offspring and the quality of life of the offspring. Secondly, how to breed, natural service or assisted breeding techniques, economic cost. Thirdly, the consequenses for the parties involved : first of all the indivual animal, then the breeder, the new owner, the veterinarians and society. Affordability of animals products , and economic cost and fair resource allocation are important factors for society when considering beeding ethics in production animals.