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Understanding exposure routes of endocrine disruptors in livestock

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Target Audience: Livestock farmers and Animal scientist

Abstract

This paper present review on various exposure routes of endocrine disruptors in livestock due to concern and wide usage of synthetic chemicals and other substances to mimic and interfere with natural hormones in livestock. Exposure to endocrine disrupting chemicals can have a lifelong effects and consequence to next generation livestock offspring. New endocrine disruptor chemicals continue to emerge and the negative and deleterious effects of such chemicals on growth, reproduction, and obesity constitute a public health issue in livestock production. The review indicates that there are various routes through which endocrine disrupting agent can get into animal body and disrupt the normal function of endocrine system: controversial use of synthetic steroid hormones, grazing contaminated pasture, drinking water, concentrate feed, inhalation EDCs substances, placental route, milk exposure and skin contact with product containing endocrine disruption chemicals. There is concern and call for animal science researchers to extensively diversify their studies in this area to come out with holistic solutions on how to minimize exposure and physio-reproductive consequences of endocrine disruptors in livestock.

Key words: *Endocrine Disruptors, Exposure, Route, livestock.*

Description of Problem

The economy of livestock production largely depends upon the reproductive efficiency of the animals; the ability of animals to reproduce efficiently is an integral component of animal production (12). However, reproductive failure is one of the most significant factors that limit the productivity of animal production systems and result in millions of dollars in lost profits annually. Inefficient reproduction in livestock may be caused by numerous factors which include wide range of endocrine disrupting agents.

According to squires (29) endocrine disruptors are chemicals that have direct endocrine effects or indirectly affect the normal endocrine system of animals they are often known as endocrine modulators (29). Hormones are disrupted and cause deleterious effects on reproductive hormones, thyroid system functioning, immune system or neurobehavioural development. Evidence has shown far reaching consequences in human (28). New endocrine disrupting chemicals continue to emerge and the concern for potential effects on humans and other animals is a concern and call for toxicity studies and the used for an appropriate model (17). Studies on endocrine disrupting chemicals like estradiol, methoxychlor and DDE have shown effects on male sexual behavior, neuroendocrine regulation of reproduction and reduce hen fertility (1).

Therefore, understanding exposure route of endocrine disruptors to animals will enable us to reduce associating our animals with chemicals or substances that will disrupt endocrine function.

Effect of endocrine disruptors

Exposure to endocrine disruptors has been associated with a myriad of adverse reproductive outcomes including reduced female fecundity, longer time to conception, higher miscarriage rates and decrease sperm motility. Endocrine disruptors also affect reproductive physiology in animal models (1). Some of the disorders that have been seen in animal studies include: oligospermia (low sperm count), testicular cancer, and prostate hyperplasia in adult males, vaginal adenocarcinoma, disorders of ovulation, breast cancer, and uterine fibroids in adult females. Disruption to thyroid functions, obesity, bone metabolism and diabetes are also linked to exposure endocrine disruptors.

Scientists has stated that "endocrine disruptors when exposed to young animals. They alter male and female gonadal development during growth stage, reduce sperm counts, distort sperm morphology and other changes in sexual behavior, such as demusculinization and feminization of male offspring (11).

Endocrine disrupting agents

Hormones: hormones act in very small amounts and at precise moments to regulate physiological development, growth, reproduction, metabolism, immunity and behavior. The hormones stabilize or balance functions in the normal body. In turn, the levels of hormones produced in the body are influenced by stimuli the body receives and are regulated by complex biological feedback systems. Any disruption to this balance can cause changes in the reproduction, development, growth, or behavior that can affect the animal or their offspring (1). Certain hormones causes endocrine disruptions are: Phytoestrogens/plant hormones such as Genistein, mycoestrogen, flavones, zearalenone, chalcone, coumestrol and so on (29) and Xenoestrogens/synthetic hormones such as 17-alpha ethinylestradiol, alkylphenols, dihydroepiandrosterone, perfluorooctonic acid (PFOA), diethylstilbestrol, ethylnilestradiol (EE2) (23).

Pharmaceutical agents: these include: Fungicides (Vinclozolin), herbicide (Atrazine), Organochlorine insecticides (endosulfan, chlordecone, kepone) and other pesticides with phenol derivatives.

Putative EDCs: these include: polychlorinated dibenzo-dioxins (PCDDs), furans (PCDFs) and polycyclic aromatic hydrocarbons (PAHs).

***Metals*:** some metals were tested in animals and found to have endocrine disruptions activities such as cadmium, mercury, arsenic, lead, manganese and zinc.

Other endocrine disruption chemicals: digylcidylmethacrylate, polychlorinated biphenyls (PCBs), bisphenol A (BPA), Polybrominated diphenyl ethers (PBDEs). Phthalates, Dichlorodiphenyltrichloroethane (DDT).

Plastics, feed, beverages, cosmetics, detergents and cleaners products contain complex mixtures of chemicals that have endocrine disruption properties (11).

Ways through which normal function of endocrine system are disrupted

Substances can disrupt the normal function of endocrine systems in three different ways:

1. They can mimic a natural hormone and lock onto a receptor within the cell. The disruptor may give a signal stronger than the natural hormone, or a signal that occurs at the wrong time.
2. They can bind to a receptor within a cell and thus prevent the correct hormone from binding. The normal signal then fails to occur and the body fails to respond properly.

3. The disruptors can interfere or block the way natural hormones and receptors are made or controlled. This interference or blockage may occur only if relatively large doses of the substances are present.

If the endocrine disruptor stimulates or inhibits the endocrine system, then increased or decreased amounts of hormone may be produced. In some cases, even very small amounts of a disruptor may have a detectable effect. In addition, small amounts of different endocrine disruptor chemicals may have a cumulative effect. In some cases the by-products of the chemicals may have greater harmful effect than the parent chemical (5).

Routes of exposure to endocrine disruptors

1. Controversial use of synthetic steroid hormones: domestic animals relate to endocrine disruptors in many ways. One is the controversial use of synthetic steroid hormones as growth promoters in beef cattle and other domestic livestock (20).

2. Grazing contaminant pasture: it has been shown that the soil and run-off from larger feedlots contain large amounts of bioactive steroids that may affect wildlife and the environment around these cattle feeding operations (3). Pig manure may contain endocrine disrupting compounds in amounts that might be an environmental concern (7). Also manure from livestock operation-both those using as well as those not using endocrine growth promoters-may spread endocrine disruptors into the environment. Yet, more research is needed in this area before firm conclusions can be made (20). Endocrine disruption is typically seen in species that are higher in the trophic ladder, as several of the anthrogenic compounds of concern are biomagnified in the food chain. In contrast, herbivorous domestic ruminants, being lower in the trophic ladder are less likely to be exposed to high concentrations of anthropogenic endocrine disrupting substances. However, it has been suggested that animals grazing in areas near incineration plants might be exposed to high amounts of environmental pollutants with endocrine disrupting properties (16).

Ample scientific studies reported that concentrations of endocrine disrupting chemicals were analyzed in cattle and sheep and regarded to be too low to impair reproductive performance in countries practicing the spreading of sewage sludge on pastures (24; 25).

3. Drinking water: one of the few reports in farm animals indicating endocrine disruption caused by environmental pollutants is regarding heifers that were drinking water in direct contact with a sewerage overflow. These animals showed increased age at first calving (21). Although the evidence of endocrine disruption caused by environmental pollutants is week, reports are more prominent when it comes to phyto-estrogens. Perhaps the most classical is the so-called sweet clover disease, caused by formononetin and genistein that bind to the oestrogen receptors and modulate oestrogen enzymes resulting in prolapsed uterus and embryonic death in sheep (4).

4. Concentrate feed: In a large survey in Sweden on the pig, which is often fed processed feed and thereby at risk of eating chemical pollutants that have been biomagnified, the burden of organochlorine contaminants at slaughter was found to be close to the detection limit of the analytical methods used (4). Ingestion of cereals that contaminated with photooestrogens causes reproductive abnormalities in livestock. Finkp-Gremmels and Malekinejad, (10) state that ingestion of phytoestrogen zearalenone (ZEA) produced by Fusarium fungi which contaminate cereals causes various signs of hyperoestrogenism, such as vaginal

prolapsed, abortions and stillbirths in pigs (10). Despite the fact that ZEA has a non-steroidal structure, it does binds to both oestrogen receptor beta and alpha and thereby causes morphological and functional effects on the reproductive system (33). It is well established that prepubertal gilts are very sensitive to ZEA, but there are also reports that prepubertal heifers may suffer from enlarge mammary glands and subsequent sterility (30).

5. Inhalation: dogs have been proposed as sentinels for human exposure to pollutants (*2;* 22). Similarly, cats have been suggested as sentinels for exposure to house dust (22). Mammary adenocarcinoma in dogs associated with elevated concentrations of certain polychlorinated biphenyls (PCB) from environmental pollutants/air (27). Endocrine disruptors that leach into the air are also taken up by bacteria and algae and those organisms are inhaled or consumed by higher organisms, including herbivores and carnivores. Pet food is a route of exposure to endocrine disruptors. For example, polybrominated diphenyl ethers (PBDEs) have been found in both pet food and serum of dogs and cats (9). Pet food has been found to contain phyto-oestrogens at levels that may have biological effect (8; 6). Dog and cat food has also been found to contain Bisphenol A (BPA) (18) as well as mycotoxins (19). Experimental studies showed that zearalenone (ZEA) affects the reproductive organs of bitches (13), but very few studies have examined adverse effects of BPA or other plasticizer (such as phthalates) in dogs.

6. Placental route: many mammals are also likely to transfer chemicals to their developing offspring in the womb. In humans and other placental animals, the developing fetus is exposed to any chemical that crosses the placenta, as well as to chemicals that have been stored in the dam`s fat since endocrine disruptors are not readily excreted from the body; rather, they are stored within fat in a process known as bioaccumulation. Also exposure of mothers during pregnancy with phthalates to offspring causes hypospadias (urogenital, congenital anomalies to offspring) (15).

7. Skin contact with product containing endocrine disruption chemicals: exposure can also occur through direct contact with products, particularly in the case of herbicides and pesticides. Cosmetics and certain insect repellents and sunscreens that contain endocrine disruptors are applied to the skin, resulting in direct exposure. Topical application of some pharmaceutical ointment that have endocrine disruption chemicals such as fungicides (Vinclozolin) serve as exposure route to endocrine disruptors to animals with skin infections.

Direct contact with dog toys that have BPA or phthalates also consider as exposure route. It was reported that "Dog toys have been found to contain BPA and Phthalates and, therefore, could represent another route of exposure (32).

8. Milk exposure: Young animals also are exposed to endocrine-disrupting chemicals through the dam`s milk supply.

9. Leaching from plastic containers, bags, paper, makers, paints and motor vehicle oils:- BPA and phthalates tends to leach from plastic containers into food they hold, thus, some chemicals are consumed inadvertently in food or drinks. Alkylphenolic compounds, PCB, Dioxins and phthalates causes breast cancer through direct contact or leaching into food substances (31).

Conclusion and Applications

1. The emergence of many endocrine disruptors in many forms and various substances has increased and these emphasized the need for a clear

understanding of various exposure route of such endocrine disrupting chemicals in livestock.

2. This will provide avenue and enable researchers from different disciplines such as reproductive physiologist, neuro-endocrinologist, breeders, pharmacologist, nutritionist and animal biotechnologists to come out with a holistic solutions of reducing reproductive consequences, and exposure to such chemicals and other related substances.

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