Prospects in the utilization of assisted reproductive technologies (ART) towards improved cattle production in Nigeria

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Abstract
Nigeria has a huge potential for cattle production but sadly this has been poorly developed. This is partly attributable to the poor utilization of assisted reproductive technologies (ART) in dairy and beef cattle breeding and production. These technologies generally include artificial insemination (AI), multiple-ovulation, embryo transfer, *in vitro* fertilization (IVF), sex determination, cloning and genetic engineering. ARTs have been applied extensively in the yearly production of millions of cattle in many developed and developing countries worldwide. This review highlights the applications and potentials of ARTs in cattle production and suggests how stakeholders in the Nigerian cattle industry can exploit these potentials. It is clear that the utilization of ARTs will enhance national livestock productivity so the Nigeria can feed her growing population and possibly increase her foreign exchange earnings by becoming a livestock-exporting country.

Keywords: assisted reproductive technologies, cattle production

Introduction
Nigeria has a current estimated human population of 198 million based on figures released by the National Population Commission (National Population Commission, 2019). On the other hand, the National Agriculture Sample Survey in Nigeria reported an estimated national cattle population of 19 million (National Agriculture Sample Survey, 2011). This is considered to be grossly inadequate in meeting the national human demand for meat, milk and other cattle products or in contributing to the gross domestic product (GDP). For instance, Nigerian's production of 0.6 million tons of milk per annum is comparatively one of the lowest in the world. This meets about 34% of the estimated annual milk consumption of 1.7 million tons. Consequently, Nigeria has to spend an average of 480 million US Dollars on the importation of milk annually (PricewaterhouseCoopers Report, 2017). Furthermore, the National Bureau of Statistics reported that about 63% of Nigerians live below the poverty line (National Bureau of Statistics, 2016). Therefore, the low availability and high cost of livestock and animal products means that many Nigerians are unable to meet their minimum daily animal protein intake.

High reproductive efficiency is essential for profitable beef and dairy cattle production. In Nigeria, poor nutrition, prevalence of cattle diseases, and the practice of nomadic pastoralism have been associated with low cattle productivity (Ducrotoy et al., 2016; PricewaterhouseCoopers Report, 2017). Furthermore, more than 99% of dairy cattle reared in Nigeria are the local indigenous breeds such as Bunaji, Rahaji and Sokoto Gudali whereas foreign breeds including Friesians, Jerseys and Brown Swiss, and cross breeds account for less than 1% (PricewaterhouseCoopers Report, 2017). Although these local breeds are genetically adapted to the tropical environment (Mwai et al., 2015), they produce far less milk than their foreign counterparts which has been attributed to genetic composition and to some extent management

practices by dairy cattle farmers (Saleh et al., 2016). For instance, the average liters of milk produced per day was 30.15 and 1.57 for the Friesian and Bunaji breeds, respectively (Saleh et al., 2016). This low productivity is worsened by poor use of modern reproductive techniques, and the lack of planned and selective breeding for improved genetic potential and maximal productivity. Instead, there is indiscriminate breeding in cattle herds resulting in decreased reproductive potentials and the spread of diseases. Therefore it is overdue for an increase in the exploitation of modern methods of animal breeding and reproduction, if ever Nigeria hopes to overcome her shortcomings in cattle and other livestock productivity.

Assisted reproductive technologies (ART)

Assisted reproductive technologies (ART) are applied extensively in many parts of the world in humans and animals to advance our knowledge of reproductive processes and to promote reproductive efficiency. These technologies generally include artificial insemination (AI), multiple-ovulation, embryo transfer, *in vitro* fertilization (IVF), sex determination, cloning and genetic engineering (Ball and Peters, 2004). In the cattle industry, ARTs were initially developed to increase the production of calves from parent cattle with high genetic potentials, but now offer many opportunities for beef and dairy cattle production.

Oestrus synchronization

Synchronization of oestrus involves the use of pharmacologic means to control oestrus and ovulation in farm animals. Generally the techniques are based on either the artificial induction of premature luteolysis using luteolytic agents, or the administration of progestagens to temporarily suppress ovarian activity. Synchronization offers several management advantages and facilitates the maximal and batch managements of AI and calving in cattle herds, thereby increasing productivity and decreasing costs in dairy and beef cattle production (Pineda, 2003).

Artificial insemination (AI)

Artificial insemination is the introduction of live spermatozoa into the genital tract of the female to cause fertilization by means other than natural mating. Semen from bulls can be extended and preserved at 4-5 °C for a few days or frozen in liquid nitrogen at -196°C for years or decades. Semen from a few high-performance bulls can be used to breed large numbers cows leading to rapid genetic improvement and dissemination of new breeds within cattle populations (Ball and Peters, 2004). Movement of preserved semen instead of live bulls would also improve trade, reduce production cost and also decrease the spread of cattle diseases usually transmitted by direct contact between cattle.

Multiple ovulation and Embryo transfer (MOET)

Multiple-ovulation (superovulation) is a pharmacologic technique applied to increase the number of oocytes released at ovulation, usually by 2 to 10 fold, thereby increasing the potential number of embryos. On the other hand, embryo transfer (ET) refers to the techniques by which embryos are collected from a female (donor) and transferred into the uterus of another female (recipient) where they develop to term. Typically, a cow ovulates a single oocyte during each reproductive cycle, and therefore may produce only 8 to 12 calves in her reproductive lifetime. However, utilizing the technology for MOET, it is possible to obtain 30 to 40 calves from a single cow over a period of a year (Pineda, 2003). Through ET, the numbers of imported highly valuable and scarce cattle breeds could be multiplied rapidly, leading to increased genetic improvement of cattle

populations (Thomasen et al., 2016). Highly valued cows that are injured or too old to carry normal pregnancy could also be made to continue producing calves via ET, rather than these animals being culled or sold for slaughter. Natural twinning ranges from 1-2% in beef cattle, but the efficiency of beef production could be also be increased in intensively managed farms by inducing twinning using ET. This technology also offers commercial advantage to farmers via a lower cost of importation of cryopreserved embryos compared to live cattle.

In vitro fertilization (IVF)

In vitro fertilization (IVF) is a technology via which oocytes are matured and fertilized outside of the female. The resulting embryos are then transferred back to the same or different females for development. Mature oocytes can be collected by flushing the oviducts shortly after ovulation. Alternatively, immature oocytes can be obtained from abattoir ovaries or by aspiration of pre-ovulatory follicles via ovum pick up (OPU) from live cows (Ball and Peters, 2004). The technology offers the potential for large numbers of *in vitro* produced embryos together with exciting opportunities for other technologies in cattle reproduction such as sex determination, cloning and genetic engineering.

Sex determination

This technology is useful when calves of a particular sex are considered to be more valuable than those of the opposite sex. For instance, dairy farmers would prefer most of their calves to be female (replacement heifers for the milking herd) whereas beef farmers would prefer bull calves for their higher body mass and beef production potential. Sex could be determined either by semen sexing or embryo sexing. Sexed semen could be applied in farms to inseminate cows with the aim of producing calves of the required sex, or for the fertilization of oocytes *in vitro* to produce embryos of the required sex. Sexed embryos could also be transferred to recipient cows to produce calves of the required sex (Pellegrino et al., 2016).

Cloning

These technologies involve embryo splitting or the use of nuclear transfer to produce genetically-identical twins or large numbers of cloned cattle. In the nuclear transfer technique, a cleavage stage embryo is split into individual blastomeres, which are then fused individually to enucleated oocytes. The resulting zygotes are then cultured and transferred to recipient cows for development to term. This offers the potential for the production of large numbers of genetically-superior cattle to drive increased dairy and beef production (Pineda, 2003).

Genetic engineering

This technology involves transferring a selected gene into an embryo so that the resulting offspring carry and express that gene later in life. Animals that carry a copy of a desired foreign gene are referred to as being transgenic (Pineda, 2003; Carlson and Lancto, 2016). In Africa, and particularly Nigeria, genetic engineering of bovine embryos may offer opportunities for the production of cattle that retain the genetic predisposition to hardiness, adaptation to the tropical environment and tolerance to tropical diseases while incorporating genetic potential for rapid growth and increased milk and beef production (Mwai et al., 2015).

Potential Interventions

There has been a significant increase in the utilization of ARTs, particularly AI and MOET, in the production of millions of cattle in many developed and developing countries worldwide. This has

l-ed to a tremendous increase in both dairy and beef cattle production in several countries such as the United States and Brazil. In Nigeria, AI has been routinely performed since 1978 at the national animal production research institute (NAPRI), Zaria. AI is also performed in a few private commercial cattle farms. Unfortunately, these efforts impact a small proportion of cattle population in Nigeria. A recent study in Northern Nigeria also revealed poor extension contact among dairy farmers, blocking the farmers from access to sources of improved dairy cattle technologies (Saleh et al., 2016). Tertiary institutions in Nigeria also present platforms for the utilization of ARTs in research that can improve animal reproduction and productivity. Many of these institutions have made considerably efforts in some areas of animal production, and in the treatment of reproductive diseases. Regrettably, there is a low potential for the application of ART, partly due to the absence of a number of equipment and facility but mainly due to shortage of human skill or training.

Clearly, an intensive application of ARTs will assist in the improvement of reproductive efficiency and productivity in dairy and beef cattle farming in Nigeria through several approaches. Skills in ARTs should be incorporated and exploited in both teaching and research in veterinary and animal science institutions. Subsequent research findings should also be utilized by the stakeholders in the cattle industry (government agencies and cattle farmers) to improve cattle productivity. In addition, there should be provision of adequate trainings, workshops and extension services in the use of ARTs to both the public and private sector participants in the cattle industry. Finally, the Nigerian government should discourage nomadic pastoralism with its attendant human conflict, while encouraging cattle ranching and the application of ARTs in cattle production.

In conclusion, it is important to note that whilst the focus here is on cattle, the principles and skills of ARTs are equally relevant to other livestock and animal species including sheep, goat, pig, horse, dog, cat, poultry and wildlife. Nigeria has a huge potential for cattle and other livestock production but sadly this has been poorly developed. It is clear that the utilization of ARTs will enhance national livestock productivity so the Nigeria can feed her growing population and possibly increase her foreign exchange earnings by becoming a livestock-exporting country.

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