Online Journal of Animal and Feed Research

Volume 3, Issue 3: 149-152 (2013) *ISSN 2228-7701*

APPLICATION OF MOLECULAR MARKERS IN FARM ANIMAL IMPROVEMENT: PROSPECTS AND CHALLENGES

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ABSTRACT: *The discovery of genetic polymorphism at the DNA sequence level has been exploited as markers to explain the observed phenotypic variability in animals. Molecular markers have proven to be more reliable than other forms of genetic markers. The overview of the applications of molecular markers in the areas of genetic diversity conservation, identification of disease carriers, parentage determination, marker-assisted selection, transgenesis, sex-determination; and the enumeration of some challenges to the application of these markers in the developing countries, especially Nigeria, form the crux of this paper. Some of the challenges include economic factors, mechanical and logistics factors, lack of funding/grants for research, IPR issues and lack of adequately trained personnel in areas of molecular genetics.*

REVIEW ARTICLE

Key words: *Molecular Markers, DNA Sequence, Polymorphism, Challenges*

INTRODUCTION

Until recently, most genetic progress for quantitative traits in livestock has been made by selection on phenotype or on Estimated Breeding Value derived from phenotype, without knowledge of the number of genes that affect the trait or the effects of each gene (Naqvi, 2007). Recent developments in DNA technologies have made it possible to uncover a large number of genetic polymorphism at the DNA sequence level, and to use them as markers for evaluation of the genetic basis for the observed phenotypic variability.

Molecular markers reveal variations even at the DNA level. They are not normal genes, as they usually do not have any biological effect, but are rather constant landmarks in the genome. They are identifiable DNA sequences found at specific locations of the genome, and transmitted by the standard laws of inheritance from one generation to the next (FAO, 2003).

Molecular markers rely on a DNA assay and have proven to be more reliable than other forms of genetic markers. Morphological (e.g. pigmentation) and chromosomal (e.g. structural or numerical variations) markers usually show low degree of polymorphism and hence are not very useful for genetic markers. Biochemical markers which have been tried out extensively have not been found very encouraging as they are often sex-limited, age-dependent and are significantly influenced by the environment. The molecular markers, however, have overcome most of these limitations. They are numerous and ubiquitously distributed throughout the genome, they are not affected by the environment and generally do not have any pleitropic effects on the Quantitative Trait Loci (QTL). According to Gholizadeh et al. (2008), the ultimate use of molecular markers would be to identify QTL in order to practice genotype selection. The development of molecular techniques has created new possibilities for the selection and genetic improvement of livestock. It entails the identification and mapping of genes and genetic polymorphisms. These polymorphisms and genetic maps are then evaluated to differentiate between markers in the expression of particular traits in a family that might indicate a direct effect of these differences in terms of genetic determination on the trait. More probably, they can prove some degree of linkage of the QTL affecting the trait and the marker. The use of molecular markers in genetic analysis offers several advantages. For example, the DNA samples can be conveniently isolated from the blood of live individuals, from tissues like sperm, hair follicle and even from archival preparations (Mitra et al., 1999). Some common types of molecular markers include, Restriction Fragment Length Polymorphism (RFLP), Polymerase Chain Reaction (PCR), Minisatellites, Microsatellites, Randomly Amplified Polymorphic DNA (RAPD), and Amplified Fragment Length Polymorphisms (AFLP).

Notwithstanding the many benefits accruable to the application of molecular markers in animal improvement, the technology is plagued by many challenges, especially in developing countries as Nigeria. This paper sets out to showcase some of these benefits and enumerate the challenges being faced in molecular markers application, with emphasis on Nigeria.

To cite this paper: Ebegbulem, V.N. and Ozung, P. O. 2013. Application of Molecular Markers in Farm Animal Improvement: Prospects and Challenges. *Online J. Anim. Feed Res.*, 3(3): 149-152.
Scienceline/Journal homepages: http://www.science-line.com/index/; http://www.ojafr.ir

APPLICATIONS OF MOLECULAR MARKERS

Genetic Diversity Conservation:

Consequent upon the rampant crossbreeding of exotic animals with local breeds in order to exploit heterosis, there has been an irreversible loss of genetic diversity among our local animal breeds. The conservation of genetic diversity is important in the sense that it encourages high level of heterozygosity in the population. Gholizadeh et al. (2008) posit that genetic variation is a prerequisite for populations to be able to face future environmental changes. Frankham et al. (2003) added that genetic diversity is necessary to ensure long-term response to selection, either natural or artificial, for traits of economic or cultural interest.

Potentially unique genes in populations should be conserved with studies using DNA markers, as their contribution to biodiversity would be greater. The primary aim of studying genetic diversity is to understand the extent of differentiation of populations within species. Population-specific genetic markers (alleles) can be generated using a range of methods available for detection of polymorphic loci (Gwakisa, 2002). The genetic characterization of populations, breeds and species allows evaluation of genetic variability. Molecular markers have been exploited to access this variability as they contribute information on every region of the genome (Pandey et al., 2006). Gwakisa (2002) reported that the most widely used molecular techniques for the study of genetic variations at the DNA level include RFLP, RAPD, AFLP, microsatellites and minisatellites.

Identification of Disease Carrier:

Infectious diseases are responsible for great losses in economic returns to the livestock farmer. Most of the serious incurable diseases result not from infectious disease-causing organisms but by defective genomes of the individual animals. Certain allelic variations in the host genome lead to susceptibility or resistance to a particular disease (Mitra et al., 1999). Kingsbury (1990) reported that a particular RFLP in the Prion protein gene was responsible for the variation in host's response to the causative agent, and the incubation time of bovine spongiform encephalopathy (BSE).

DNA polymorphism occurring within a gene helps to understand the molecular mechanism and genetic control of several genetic and metabolic disorders and allows the identification of heterozygous carrier –animals which are otherwise phenotypically indistinguishable from normal individuals. The PCR-RFLP assay has been used to identify carrier animals possessing the defective recessive allele in bovine leucocyte adhesion deficiency in cattle (Shuster et al., 1992), hyperkalemic periodic analysis in horses and malignant hyperthermia in pigs (Fujii et al., 1991). Georges et al. (1993) identified carrier animals of weaver disease in cattle using microsatellite (TGLA 116) marker.

Determination of Parentage:

The identification of parentage in segregating populations generally takes place by means of the exclusion principle. That is, presence at some genetic locus in the offspring of an allele not found in either of the putative parents effectively excludes the particular parental pair from biological parenthood. Highly polymorphic DNA fingerprinting markers have been reported to be very useful in parentage testing (Mitra et al., 1999). Molecular markers can be employed for sire identification in Artificial Insemination programmes.

Marker-Assisted Selection:

This is a genetic engineering technique which involves the incorporation of DNA markers for selection, to increase the efficiency of the traditional methods of breeding based on phenotypic information. Molecular marker analysis allows the identification of genome segments, QTL contributing to the genetic variance of a trait and thus to select superior genotype by environment interaction (Gholizadeh et al., 2008). Therefore selection for favourable QTL effects based on molecular marker studies has great benefits to offer for the improvement of such economic traits.

Transgenesis:

This is a procedure in which a gene or part of a gene from one individual is incorporated into the genome of another one. According to Mitra et al. (1999) findings, the starting point of this technology is the identification of the genes of interest. In this context, molecular markers can serve as points of reference for mapping the relevant genes that would be the first step towards their manipulation. Molecular markers could as well be used to identify animals carrying the transgenes for the purpose of multiplication.

Sex Determination of Offspring:

Molecular markers can be applied in the determination of sex of pre-implantation embryos. This can be achieved by using as probes, Y-chromosome-specific (male-specific) DNA sequence. Peura et al. (1991) reported that using the PCR-based method of sex determination has the advantage of being carried out in less than five hours with almost 100% accuracy. It is less invasive, unlike other cytogenetical methods, and can be done at an early stage of the embryo (Machaty et al., 1993).

The sexing of pre-implantation embryos can serve as an important tool for improving a herd for a desired purpose.

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CHALLENGES TO THE APPLICATION OF MOLECULAR MARKERS

Economic factors:

According to Dekkers and Hospital (2002), "economics is the key determinant for the application of molecular genetics in genetic improvement programmes. The use of markers in selection incurs the costs that are inherent to molecular techniques." Developing costs (e.g. identifying molecular markers on the genome, detecting association between markers and the traits of interest) and running costs (e.g. typing individuals appropriate in the selection programme) can be quite expensive. Besides, the cost of importation of the technology from developed countries could be so outrageous that it may out-weigh whatever benefits that could be derived from it.

Mechanical and Logistics factors:

In Africa presently, functional Biotechnological and Genomic Centres are not very common. Apart from the International Livestock Research Institute, Nairobi, Kenya and the University of Agriculture, Abeokuta, Nigeria, many other centres are lacking in equipment for processes such as DNA extraction & electrophoresis, PCR, hybridization, and amplification. Omitogun (2007), noted that even many well-equipped laboratories in some of the Research Institutes, Universities and Polytechnics in Nigeria, have become 'white elephants' because of lack of materials or consumables to fully use the equipment available. Since molecular markers have to be imported from countries like the USA and the UK, researchers have to place orders long in advance when the need to use such markers arise ,and the delivery of these markers to their point of use may take several days. This long delays impacts negatively on the potency of the imported markers, which consequently complicate or distort experimental results.

Lack of Funds/Grants to Researchers:

The researches involving molecular technologies are being hampered in Nigeria and other developing nations due to the inability of researchers to access grants and funds. Many times in Nigeria, researchers are denied opportunity to secure research grants because their institutions or their basic affiliations could not provide the basic equipment/facilities required to effectively carry out some researches (Olowofeso, 2011). Sometimes when research grants are provided, the amount is hardly sufficient to procure all the necessary reagents and other consumables. But it is common knowledge that meaningful research especially molecular studies require a lot of funds.

Erratic Power Supply:

In Nigeria and some other African countries, power supply is very erratic and unsteady. At times for days running into months, some areas do not have electric power supply due to one problem or another, and when provided, might last for few hours. Many Universities and Research Institutes are not left out of this malady. Students and researchers alike have been forced to terminate their experiments involving constant power supply as a result of this menace. Olowofeso (2011) argues that this erratic power supply appears to be the most challenging factor impeding human activities in developing countries. Molecular markers need very cool environment at all times and storage materials like refrigerators and deep freezers connected to a regular supply of electricity is necessary, as markers devoid of a cooler environment will not work when employed in PCR technology.

Lack of adequately trained Personnel:

The application of molecular markers to the improvement of animal species in Nigeria is also being hampered by the non-availability of enough number of adequately trained personnel with the requisite practical experience in the Universities. Some who are well trained have been rendered redundant because of non-motivation, while others have opted to move to the developed countries to work. It is therefore advocated that training and re-training of personnel be carried out to forestall the problem of inadequate human resources.

Intellectual Property Rights (IPRs) issues:

IPRs is playing an ever greater role on food and agriculture in developing countries. It is influencing generally in the negative sense, the quality of agricultural research carried out and the nature of research collaborations between the public and private sector and between developing and developed countries. It is obvious that IPRs may also impact on developing countries such as Nigeria. Where patents are not sought, information on innovations is kept secret, and has negative impact by denying the developing countries access to potentially useful information.

CONCLUSION

It is no doubt that molecular markers have the potentiality of improving the genetic lot of animal species. It is advocated that Government be more pro-active in tackling the challenges enumerated herein. Public and private sectors are enjoined to look into partnering with Universities and Research Institutes to develop our own molecular technologies.

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