Recent Trends In Livestock Innovative Technologies

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Bentham Books

Recent Advances in Biotechnology

(Volume 7)

Recent Trends In Livestock Innovative Technologies

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ISSN (Online): 2468-5372

ISSN (Print): 2468-5364

ISBN (Online): 978-981-5165-07-4

ISBN (Print): 978-981-5165-08-1

ISBN (Paperback): 978-981-5165-09-8

First published in 2023.

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FOREWORD

It is a great privilege for me to be given a chance to contribute a foreword to the volume on intensive livestock production that was published by Hafiz Ishfaq Ahmad and Muhammad Hamid. It is helpful to have knowledge on so many of the topic's facets compiled in one book because it is still a contentious subject. In point of fact, the range that is covered is really broad since it encompasses all of the animals that are used for food and includes a very helpful chapter on fish farming, which is an industry that has been so underutilized in this country but has been very successful in a number of other nations. Biotechnology has the potential to improve animal productivity in a number of ways, including increased growth, improved carcass quality and reproduction, enhanced nutrition and feed utilization, enhanced food quality and safety, enhanced animal health and welfare, and reduced resource waste through more effective utilization of available resources.

In the area of quality assurance programs, a number of biotechnological strategies can be assessed. This should be helpful for producing animal products with guaranteed quality and safety in terms of public health. Recent advances in reproductive biotechnologies have provided a powerful tool that can be used to improve animal production and address the challenges of livestock production in the future. Contemporary advances in reproductive biotechnologies have provided contemporary advances in reproductive biotechnologies. The implementation of these technologies will assist in managing the constrained resources that are currently accessible while simultaneously increasing the need for the production of food. The subject of nutrition is given a major role throughout, which is obviously of utmost significance when dealing with animals because these creatures must have all of their food provided for them. The disease will occur in whichever system is employed in the management of animals; however, the disease patterns and the disease potential will differ depending on the system. Even if there is an increased risk of disease in intensive settings, there is also a greater potential for the successful application of preventive medicine. Although intensive management is not a new concept, there are currently more animals of several species being kept in this manner than at any other time in history. Under current circumstances, which include decreased acreage and economic strain, it is quite obvious that intensification is here to stay.

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PREFACE

The livestock sector globally is highly dynamic. In developing countries, it is evolving in response to rapidly increasing demand for livestock products. In developed countries, demand for livestock products is stagnating, while many production systems are increasing their efficiency and environmental Sustainability. Historical changes in the demand for livestock products have been largely driven by human population growth, income growth and urbanization. The production response in different livestock systems has been associated with science and technology as well as increases in animal numbers. In the future, production will increasingly be affected by competition for natural resources, particularly land and water, competition between food and feed and the need to operate in a carbon-constrained economy. Developments in breeding, nutrition and animal health will continue to contribute to increasing potential production and further efficiency and genetic gains. Livestock production is likely to be increasingly affected by carbon constraints and environmental and animal welfare legislation. The growing demand in the developing world and stagnant demand in industrialized countries represent a major opportunity for livestock keepers in developing countries, where most demand is met by local production, and this is likely to continue well into the foreseeable future. At the same time, the expansion of agricultural production needs to take place in a way that allows the less well-off to benefit from increased demand, which moderates its impact on the environment. This book attempts a rapid summary of the present-day state of livestock production systems globally in relation to recent trends, coupled with a brief assessment of whether these trends are likely to continue into the future. The key drivers underpinning past increases in livestock production are outlined, and the status of both intensive and extensive production systems in the developed and developing world is described.

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CHAPTER 1

Livestock Domestication

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Abstract: Domestication of animals was one of the most significant changes in human history, beginning with a long-term connection between hunter–gatherers and wolves more than 15,000 years ago. Between 11,000 and 4,000 years ago (approximately the Neolithic to the Bronze Age), when mixed-crop farming communities emerged, a variety of additional species, including sheep, goats, cattle, pigs, poultry, and horses, were introduced into human society. The domestication of livestock had a profound impact on human society. It allowed humans to produce more food and live in larger, more complex societies. It also led to the development of trade and commerce, as surplus animals and animal products could be exchanged for other goods. Animals have played various roles since their domestication, ranging from being tolerated to being revered in ceremonial activities to supplying humans with additional advantages, such as food, clothing, building materials, transportation, herding and hunting. The diversity of phenotypes, seen in various domesticated species has provided generations of scientists with a useful model for studying evolution. The domestication process has led to the development of many different breeds of livestock; each adapted to specific environments and tasks. In modern times, livestock domestication continues to play a significant role in food production and agriculture, and it remains an important part of many cultures worldwide.

Keywords: Biotechnology, Domestication, Evolution, Genomics, Livestock.

1.1. INTRODUCTION

There are almost 150 species of domestic and wild ruminants. Ruminating mammals include sheep, goats, cattle, yak, camels, llamas, giraffes, deer and antelope. The wild ruminant's population is approximately 75 million, native to all zones except Antarctica. Approximately 90% of all species are present in Eura-

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sia and Africa. These ruminant species are found within an extensive range ofenvironments and habitats, from tropic to arctic and from forests to open grasslands. The population density of native ruminants, which includes goats, sheep, and cattle, is difficult to estimate precisely because it varies significantly between regions and countries. However, according to the Food and Agriculture Organization (FAO), as of 2020, the global population of goats, sheep, and cattle combined was approximately 4.1 billion. [1]. More exclusively, small ruminants such as goats and sheep have adaptive abilities to live and create in composite atmospheres, whether arid high altitude or extreme cold. Generally, small ruminants are proficient converters of forage feeds, whether farmed in temperate, arid, or semi-tropical environments. Small ruminants have a great advantage compared to large ruminants in their low cost, small size, appropriateness to small holdings and, in numerous developing countries, their triple function use for meat, milk, and fiber. Distinctive in the world tendencies in livestock statistics over the past twenty years is the stable increase in sheep and goat numbers [2]. Domestication is the process of prompt, artificial and intensive selection, and the studies on animal domestication have mainly focused on evolutionary biology" [3]. Study on domesticated animals has certain major gains over studies of wild animals: descendants are commonly known, samples are usually not restricted and numerous breeds are inbred, and gene variant are fixed that are responsible for particular phenotypic characteristics. These characteristics of domesticated animals made them valued models for genetics and molecular studies of the coat-color inheritance of domesticated animals, including laboratory mice [4]. Therefore, genetic differences, a major requirement for selection, have been restricted in early domesticated populations. To comprehend these divergences, pooling data from diverse research areas, such as molecular biology and animal genetics, is essential. These data can be used to highlight the following questions: (i) why do domesticated animals have a greater degree of color variation as compared to wild descendants; (ii) when did this phenotypic discrepancy rise; and (iii) was deliberate breeding or genetic drift the key influence stirring this process [4].

1. 2 EVOLUTION OF ANIMAL DOMESTICATION

The origin of animal domestication is an antique but critical question. As a breakthrough for the agricultural uprising, zoo-archaeological methods have been involved in human evolution studies [5]. During past years, molecular genetic methodologies have been used to explore this problem [6]. Scientists can find the descendants of domesticated species through phylogenetic studies on genomic data of existing domesticated species and their wild ancestors [7]. The genetic data mostly contained mitochondrial sequences derived from the maternally innate genome that is non-recombining and has restricted power to recognize or compute hybridization concerning geographically discerned domestic and wild populations. The development of sequencing technologies has permitted the assessment of nuclear genomes analyzed in a population genetics scheme, thus overwhelming the boundaries of mitochondrial data sets [8]. Several studies demonstrated that pig populations domesticated in one place and then relocated to a new area successively gained the mitochondrial signature of native wild populations [9]. The same is correct for other taxa. The yellow leg trait was developed *via* introgression from grey jungle fowl and possessed by several South Asian indigenous chicken breeds [10]. African cattle are mixtures of "taurine" and "indicine" that possess both Y-chromosome signature and mitochondrial signals [11]. Successive admixture between wild and domestic populations that were never domesticated is stated as "introgressive capture" [12].

1. 3 DOMESTICATION HISTORY: FROM TRADITIONAL FARMING TO MODERN BREEDING

The foundation of domestication is linked with cultural progression from hunting to farming in ancient civilizations during the Neolithic, possibly with the exclusion of the dog, which was the most likely earlier domesticated animal [13] and diverged for different species concerning both locations and timing [14 - 16]. In some situations, skin and coat color can be valued markers for solving these opinions. For example, researches on the molecular context of yellow and white skin show a hybrid source of domesticated chicken [10]. However, in most domesticated species, few patriline's and matrilines' evolutionary ancestries exist to determine multiple roots of domestication in certain species [17, 18]. These molecular genetic data show that domesticated species' geographical distribution arose from an inadequate number of domestication cores [19]. The genetic variability of present breeds is frequently condensed through inbreeding. This decline in genetic diversity is started by the reproductive segregation of individuals from their common ancestors at domestication. Consequently, the genetic diversity of all domestic species is affected by bottlenecks. The domesticated species were isolated from their origin and adopted different climatic conditions in new regions. These new surroundings encouraged artificial selection to adopt new habitats, ultimately causing the fixation of preferred allelic variants. For example, horses were mainly domesticated for meat and milk during their domestication [20], but later on, they became animals for transportation, warfare and sport horse racing. These changes in phenotypic selection eventually changed the genetic markers impaired by selection (Fig. **1**). Moreover, during the Neolithic, gene flow among domesticated species was low due to the small size of the human population.

CHAPTER 2

Genomics and Biotechnological Advancements in Fisheries, Poultry

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Abstract: Biotechnological advancements have started gaining importance for subsidizing conventional breeding strategies to the latest cost-effective techniques that enhance the yield and are robust. This effort aims at showcasing the different strategies adapted to bring up the production curve in fisheries, poultry and livestock by using the latest biotechnological assays and procedures. A better understanding of disease resiliency in animals and increasing the growth rate of fish, domestic animals and poultry birds can help cope with the increased demand for milk, meat, eggs and proteins worldwide. The genome engineering tools, such as CRISPR-Cas9, single nucleotide polymorphism, somatic cell nuclear transfer, zinc-finger nucleases, Sperm Transfection–Assisted Gene Editing (STAGE) and cloning, possess the ability to alter the genome either by knocking in or knocking out of the genes for better selection of the breeds. Genomic estimated breeding values (GEBVs) are devised using the gene markers without prior knowledge of the exact gene location across the chromosome. These predictive values help in gene insertion or gene deletion in the host. The breeding programmes initiative can bring up advantages by managing the resources and growing the yield. The biotechnology applications should be incorporated with progressing customary reproducing and improvement programs to meet the growing challenge of feeding the population of 9 billion.

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Keywords: CRISPR-cas9, Genomic estimated breeding values (GEBVs), Sperm transfection–assisted gene editing (STAGE).

2.1. INTRODUCTION

In previous decades, the advancement in technology and scientific tools have greatly increased poultry, fisheries and livestock production. In the past 30-35 years, advancements in developing the most beneficial and genetically enhanced poultry, which can increase its production level even during harsh climate situations, have played a tremendous role in moving the poultry produced in rural areas to a more modern and mature industry. It has been observed that the need for food production by animals is foreseen to become high by 70% by 2050 [1]. Genomic selection has been introduced in livestock, producing excellent results in livestock production throughout the past 10 years, and it needs more improvement. The cost-effective, more complex genomics may include microbiome data, genomic and transcriptomic or epigenomic are mixed with advanced technology tools for collection and use is a major step in the higher production of livestock [2]. The emergence of Next-generation sequencing has increased the gridlock of research in fisheries genomics by decreasing the costs and increasing the DNA sequencing speed immensely [3]. By analysis of the previous 10 years' published articles in East Africa, there is a research gap in the Poultry meat supply chain (PMSC) in East Africa [4]. There is a noticeable lack of literature on managing poultry production during heat-stress climates in rural areas [5]. The advent of livestock-associated methicillin-resistant *Staphylococcus aureus* (LA-MRSA) has boosted the need to discover its effective treatment and prevention. However, still, more research is required in this area [6].

In this study, the focus is on the current status and challenges in the genomics of aquaculture. These different tools are used for increasing the production of aquaculture and fisheries resources and management of these in any climate situation. Precision genome engineering (PGE) tools for rapid and directed change of poultry genomes have created a new approach to precision poultry breeding. It is now possible to introduce intra- or inter-species single nucleotide polymorphisms (SNPs) into a chicken line for improved productivity. The new era ushered in by these new PGE tools means that desirable SNPs, or the gene variants associated with them, can be introduced into a line of genetics in a single step rather than taking several reproductive rounds, including screening. This could be the beginning of a new agricultural revolution, dramatically reducing the time taken to improve chicken lines for particular production environments and introducing resilience to specific diseases that may threaten the security of the food production system.

2.2. GENOMICS IN AQUACULTURE: CURRENT STATUS AND CHALLENGES

The aquaculture industry has frequently been inventive and visionary in utilising innovations to develop creation further. Utilizing genomic apparatuses to more viably use genetic variety in financially significant characteristics utilizing maintainable rearing developers is paramount to proceed with effective development and strength of aquaculture production [7]. A conference that deals with genetics and genomics of aquaculture, the ISGA (International Symposium on Genetics in Aquaculture) is held every three years; this symposium helps to learn researchers the different fish species and to provide information and ideas by using genetics, biotechnology, marker-assisted selection (MAS), genomic selection (GS) and their integration can lead to improvement in production [8]. Since 2005, the advances in next-generation sequencing (NGS) technologies have been substantial [9]. Under USDA National Research Support Project 8 (NRSP-8), several aquaculture species genomes have been sequenced; such species including catfish [10], Atlantic salmon [11], rainbow trout [12], tilapia [13], striped bass, Pacific oyster [14], eastern oyster, and Pacific white shrimp as well as yellow perch and bluegill sunfish [15]. The two aquaculture species, *i.e.*, tilapia and salmonid species, have tremendous genetic improvements because of the advanced genetic tools used for their production. The growth rate is an important characteristic of breeding aquaculture [16]. A selection candidate's growth-associated traits can be measured directly by the candidate. Sib-testing techniques are used to check disease resistance and traits of carcass quality. For instance, specific pathogen resistance phenotypes are reported performing large-scale experiments with thousands of full and half sibs of selection candidates. The processing plant uses similar family-based designs to report carcass-quality traits [17].

The duplication of whole genome events is a serious challenge in the genomes of some teleost fish. Some other teleost fish genomes, such as common carp, Atlantic salmon and other salmonid fishes, are more complicated such as allotetraploid, because of many whole genome duplications. Polyploid fishes are more challenging. *Acipenserformes*, family Acipenseridae, genus Acipenser can process 500 chromosomes and are reported as octoploid [18]. A large amount of sequencing data and sharp assembly algorithms will be needed for complex genomes assembly. Some extrinsic factors may affect the genomic assembly qualities. These may be the sample quantity, sequencing strategy and assembly methods. Encouragingly, genomics' benefits in aquaculture production are higher than terrestrial production [19]. Disease resistance is a harsh condition in which aquaculture and catfish production is lost up to 40%. These diseases are massively causing deaths, production loss and financial crises from the investment in

CHAPTER 3

Successful Genomics and Biotechnologies in Livestock Production

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Abstract: Health maintenance will be considered one of the major challenges for effective livestock production in the next decades. The demand of the world for food products from animals is estimated to increase by more than 70% by the end of 2050. To meet the increasing demand, such advanced methods and techniques are required, which have minimal effect on the environment. Over the last 10 years, the selection of genomics has been presented in various major livestock species. This selection has shown almost double the progress in genetics. Though, extra improvements in the field of genetics are required. The information on genomics with increased complexity (including epigenomic, genomic, microbiome data and transcriptomic) have been combined with the advanced biotechnologies for the purpose of a cost-effective method of collection and use, which will be then responsible for a most important contribution. Such technologies on implementation will permit genetic gains in the traditional traits of milk production along with low heritable traits, *i.e.*, fertility and health.

Keywords: Biotechnologies, Genomics, Genetic improvement, Livestock, Production.

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3.1. INTRODUCTION

Since the 1960's, the productivity of global livestock (comprising of egg production in poultry, the weight of carcass in species producing meat and milk yield in dairy animals) has increased up to 20–30% due to improvements in disease control, genetics, and nutrition [1]. Infectious diseases enforce a substantial economic burden on livestock production. Until now, antibiotics, anti-parasitic drugs and vaccines are major countermeasures to control the diseases. These countermeasures have been effective in a few cases, but antimicrobial and anti-parasitic resistance is a cause of serious concern. Also, the targeted treatment to control the disease is only beneficial up to a certain limit. In contrast to this background, most alternative methods for the maintenance of animal health are nutrition management, genetic improvement and breeding of livestock animals that are naturally strong (the ability to withstand the exit from the best environment) [2].

Genetic improvements have been obtained through cross-breeding, selection within the breed and substitution of the breed; despite cross-breeding and breed substitution (one-off measures, selection within the breed shows more genetic progress. For obtaining more accuracy in estimated breeding values (EBVs) of individuals, selection within the breed was dependent only on sophisticated statistical methods, *i.e*., mixed model methodology. For a more effective distribution of elite genomes, a remarkable improvement of genetics has been obtained in various species through combining selection within breed with reproductive technologies, *i.e*., artificial insemination, embryo transfer, *in vitro* fertilization, semen sexing). This combination of selection within the breed with reproductive biotechnologies has reported a 1-3% annual genetic gain. Therefore, it has been concluded that the most effective way to reduce the detrimental environmental effects of livestock is to increase livestock production through genetic improvement [1].

The concept of genomics emergence was introduced in the 1980s. This emergence created 'Marker Assisted Selection' (MAS). In MAS, genes and genetic variants influencing agriculturally significant traits will be identified to increase the genetic response. Quantitative trait loci (QTL) have become a global chase in all livestock species. QTL was mapped first with linkage analyses and then with Genome-Wide Association Studies (GWAS) with major impacts on economically important traits. Still, both of them did not have such a large proportion of heritability that they provided them with useful tools of selection on their own. From the breeding industry, MAS met with limited enthusiasm when genomic selection (GS) was proposed. GS, in its simplest form, makes a similar assumption as that of standard selection of EBV, which shows that for interested traits, additive effects of various variants are reflected by genetic variance with small effects dispersed uniformly throughout the genome. When GS was tested and adopted as the most effective and alternative method compared to that of the costly and time taking 'Progeny Testing Program' (PTP) by the breeding industry of dairy animals, the 'Single Nucleotide Polymorphism (SNP) Arrays' transformed into the most affordable reality. Until now, a large number of dairy animals have been genotyped throughout the globe. Nowadays, breeding companies consider the GS an important tool that would give double genetic progress compared to other tools [3].

Though, GS now a day is estimated to make genetic progress (up to 20-fold in dairy layer hens and dairy animals) with additional modest gains in livestock species. GS is insufficient to meet the 70% expected increase of animal products in the world demand by the end of 2050. Further additions and improvements are needed to meet such an increased target [1, 4].

The 'Next Generation Sequencing' (NGS) biotechnologies also provide major opportunities for tackling the problems related to pathogenic illness. The usage of novel genomics also aids in the development of treatment along with effective breeding programs. These genomic tools may be helpful in reducing the reliance on the treatment of antibiotics and mitigating the long-term effects of fighting infection [2]. Therefore, it is suggested that genomics should be responsible for tackling the challenge of improving the health of animals [5]. Recently, genome selection and genome analysis have been applied. Hence, it is now believed that the discoveries of genomics and the usage of advanced genomic and genetic tools are responsible for increasing the efficiency of animal production [6]. It is also notable that for the sustained production of livestock along with increasing challenges of production, health and reproduction, it is also important to start using biotechnologies [7]. This chapter highlights the successful genomics and biotechnologies used to improve livestock production. The overview of genomic biotechnologies is given in the following paragraphs.

3.2. OVERVIEW OF 'OMICS' BIOTECHNOLOGIES FOR LIVESTOCK SPECIES

The omics technologies are primarily the universal detection of genes (genomics and epigenomes), mRNA (transcriptomes), proteins (proteomics) and metabolites (metabolome) in a specific biological model. Only genomics will be reviewed in this chapter. A remarkable development in the genomics field has been seen in the last few years. However, the greatest challenge is integrating the different kinds of "omics" data to provide a vision of the complex biological systems within living organisms [8]. A large gene number controls most of the biological traits which

CHAPTER 4

Application of Biotechnologies in National Livestock Development Programs

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Abstract: Globally, livestock production is growing faster than any other sector and by 2025, livestock is predicted to become the most important part of the agricultural sector in terms of its added value to the national economy. The use of biotechnology will lead to a distinct shift in economic returns from livestock. 43% gross value of agricultural production is currently held by livestock. If we speak about the role of livestock in developed countries, then it holds more than 50% of total agricultural production. At the same time, in the case of developing countries, this share reduces to almost 30% due to a lack of biotechnology or not using enough modern sources. In most developing countries, biotechnological applications relating to livestock need to be suitable for animal owners who are resource-poor small-scale operators who own little or no land and few animals. The rapid increase, in developing countries, of livestock population is due to a rise in population growth, and a desire to change their lifestyle. Urbanization is also a source of passive or active income for them.

Keywords: Agriculture, Biotechnology, Livestock, Molecular markers, Transgenic.

4.1. INTRODUCTION

One of the major benefits in agriculture research and technology is to increase the buying power of people experiencing poverty because both average income and access to staple food products, are improved [1]. The rapid growth of livestock has resulted in global economic growth by increasing and enhancing the value of land, labor, services and non-agricultural products. Increasing animal production through biotechnology can have a significant impact on feed [2]. This is because.

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poor people spend a relatively large part of their extra income on feed, especially when technology targets the poorest producers [3]. However, research shows that the commercialization of agriculture is reducing food security for people experiencing poverty [4].

As technology improves milk, meat and egg production, it is expected to bring major changes in other areas, such as nutrition, disease prevention, health care and other management practices. Biotechnology is promising and is currently being used in this field- Innovative green technologies (factory control, water management, *etc*.). However, farmers often fragmented and systematised many components of these technologies [5]. The order of execution depends on the availability and potential cost savings. Sequencing software has been studied in detail as a technology for growing rice and wheat, but comparative livestock studies centered on developing countries are scarce. Biotechnology is a promising new tool for developing technologies applicable to agriculture. The challenge is to focus this ability on the challenges of developing countries [3].

4.2. LIVESTOCK ECONOMY AT THE NATIONAL LEVEL

Livestock is becoming increasingly important for agricultural development in emerging countries. Although agriculture and its share of Gross domestic product (GDP) are declining, demand for livestock products is a function of income driven by the continued growth of per capita income, urban population growth and growth of animals. Livestock contributes to social and economic development in many ways, including increasing income and employment in rural areas and reducing poverty [6, 7]. While the role of livestock in ensuring food security in mixed agriculture and agricultural systems is well known, the importance of livestock goes beyond direct food production. Agriculture is thus an important source of income and employment, alleviating poverty and facilitating the distribution of income among the small landowners and landless people, who make up the majority of the rural population and the nomadic majority. In addition, livestock can easily earn income, which acts as a safeguard against crop failure, especially in adverse conditions [8]. Livestock actively contributes to the environment by using plant residues and by-products as animal feed. Animal owners in developing countries are often small and vulnerable, have little land and animals to grow in adverse climatic conditions [9], and have limited purchasing power and access to resources and agricultural capacity [10]. The poor nomadic environment is rapidly deteriorating due to the limited fragmentation of animal resource farms, reduced land resources, and increased pressure on humans and animals. Low livestock productivity in many developing countries reflects, among other things, inadequate veterinary and livestock services[11]. Governments traditionally provide veterinary services, but financial constraints limit access and effectiveness to public services [12].

4.3. GLOBAL ADVANTAGE OF LIVESTOCK

The genetic, species, number and diversity of agricultural ecosystems are nationally recognized as a valuable resource for the genetic improvement of livestock worldwide. Livestock from some developing countries, an integral part of fragile ecosystems, is a rich source of species diversity, and buffalo, sheep, goats, camels and zebras have been present in local environments for many years. It is an important resource for residents of that region [13]. Livestock in developing countries has many advantages over production in developed countries.

For example,.

● Unique and valuable characteristics of buffalo, cattle, sheep, goat and camel production.

● Low input production system.

● Low unit production price.

● High biodiversity.

● Breeds with specific resistance to stress and disease.

● Ability Animals can survive on large-scale feed.

● Possibility of developing biomedical products with great benefits.

● Ability to spread microbial food, animal feed and leather industries.

● Systems adapted to the environment of integrated production areas.

● Ability to integrate knowledge and industry [3].

Some breeds from the developing world are particularly important on a global scale. Some are:

● Buffalo, which produces the high-fat or protein-rich milk needed to make mozzarella.

● High fertility goats Black Bengal goats.

CHAPTER 5

Omics and Bioinformatics for Livestock Production

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Abstract: Due to increasing knowledge about the function of genes and proteins in various living organisms, the genomics of farm animals is a major concern for researchers. Different applications like increased milk, meat, and wool production are the main drivers of the increase in farm animal genome activities. Data about the gene sequences of different organisms, like fish, cows *etc*., can be obtained from warehouses that are expanding quickly. However, this is protected and owned by many data processing and storage authorities. In this chapter, we will discuss genome project measures and animal bioinformatics that increase scientists' interest in advancing developments in the field.

Keywords: Bioinformatics, Genome, Livestock, Omics, Proteins.

5.1. INTRODUCTION

Genomics may be defined as the field of science which involves the study of physiology, role and the relationship between genes and an individual's genome [1]. The beginning of this discipline was to discover the building blocks of DNA, and now it involves the complete genome sequencing of any living organism [2]. Now the development has been done in the research of genomics to develop a full map of the sequences on which genetics is based [3]. As a result, scientists have the aim to obtain a master's knowledge about the role of different cells at the level of DNA in the future. These efforts would ultimately result in finding out the details about gene regulation, which involves the regulation by a protein or a gro-

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up of proteins. When individuals face problems while dealing with the bulk of data, many databases can solve these problems. But there is also the increasing number and complications of data processing tools that are overwhelming. This fact is similar to the scientists involved and interested in proteomics. The structural and functional study of proteins, known as proteomics, attracts scientists in biomedicine. The next key turns over in the era of "post-genomic" is expected to be the extensive application of the knowledge of the structure of protein while designing rational experiments. Modern computational techniques can now develop a structural model that can compare to the crystal models using only a fraction of the cost [4]. In these computational techniques, the main issue is to consider all the physical and chemical aspects of a large number of proteins [5]. To solve this, researchers have now developed a new and vast field known as bioinformatics, which uses cutting-edge computer programs to analyze sequences. Bioinformatics involves the methods to store, retrieve and then analyse the data of an organism like DNA/RNA/proteins sequences, their formation, way of function and interactions [6]. This field not only focuses on the computer, biological and management sciences but also involves using all the tools that can be used practically for the development, proliferation, processing and then understanding of the information related to biological sciences [7].

5.2. DATABASES

Due to the complete information about the genome sequence of many organisms, heaps of new information and knowledge about the role of conserved and non-conserved regions can be concluded [8]. The arrangement of different forms of DNA and protein sequences in the genome is the key component of bioinformatics [6]. Interpretation and understanding of these biological sequences are the initial steps, followed by management and investigation of sequences. Sequences can be arranged again based on examination. There are some databases for specifically for DNA sequences [9] and protein sequences [10] with available analytical tools [11]. The purpose of these tools is to help in searching the sequences which are similar to each other and have a homologous relationship among them. Utilization of such tools could be helpful in improving the databases which contain data about sequences [12]. Due to the notion of global databases, such data and databases are available publicly [13].

5.2.1. Animal-Specific Databases

When research is conducted in the field of pathology and physiology, farm animals are considered as models [14]. The reproductive anatomy of these model animals has more resemblance to humans as compared to the rodents [15]. In the case of structural similarity, pigs and humans have the same digestive system. There are some features of the model animals in case of functional similarity, showing them as excellent sources for research [16]. For the past several years, scientists have modified the genome of the experimental animals by first finding out the required characters and then by selecting the experimental farm animals in which these characters are to be modified. Afterwards, these are transferred to their offspring [17]. This research has helped to minimize the congenital diseases in the animals because the animals that are carriers of these diseases may be refrained from breeding by the process of selection [18]. When scientists observe different types of phenotypes in different time intervals, they can predict the changes that occur in different individuals in the population [19]. Due to the availability of resources to study genomics, this will eventually result in economic advantages. For example, DNA extraction is a powerful tool to extract the DNA from meat samples to ensure that the quality of the meat has not been compromised [20]. To study and store these DNA or other sequences, many species-specific databases have been generated and are available (Fig. **1**). Animals of economic and medical importance have been readily studied and sequenced extensively.

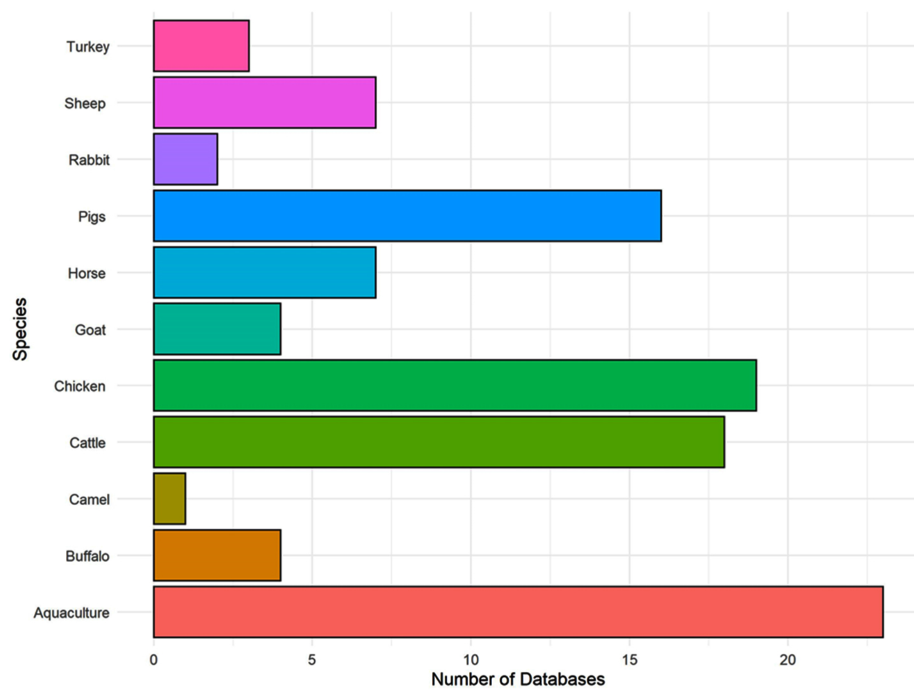

Fig. (1). Number of species-specific databases available online.

CHAPTER 6

Genetic Improvement of Indigenous Sheep And Goats

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Abstract: The breeding of small ruminants has a huge social and environmental impact globally. Due to rising production costs concerning milk prices and customer desire for harmless and superior quality food, efficient features have become crucial for effective breeding programs. Most farmers are unaware of the strategic value of genetic improvement and lack the incentive to support breeding projects on their own, so government money has been the primary funding source for breeding initiatives. Genetic markers have been employed to help with paternity determination, confirmation, variety protection, and breeding standard selection. An integrated strategy is required to assist in the creation of breeding programs and solve the problems of improving indigenous breeds, like sheep and goats. Genome selection and innovative reproductive technologies are examples of scientific progress that will allow for quicker and more effective genetic improvement. The whole strategy should improve the competitiveness and long-term survivability of the indigenous population. This chapter is focused on determining particular breeding targets of sheep and goats that represent the sector's priorities and demands, gene-assisted selection, and the capabilities of disease-free indigenous populations.

Keywords: Farm animals, Genetic improvement, Genetic modification, Goats, Indigenous breeding, Sheep.

6.1. INTRODUCTION

Small grazing animals have traditionally been grown in grassland systems, with the more productive areas generally utilized to feed goats and sheep. Hilly places, Poor soils, and dry regions have all been inhabited by goats; the worldwide sprea-

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ding of small ruminants and their varieties is mainly due to these factors. From the middle of the nineteenth century, the requirement for milk and meat products increased, so the improvement of procedures such as automation and genetic breed enhancement enabled production escalation to meet this need at a reasonable price. This type of improvement began in developed nations and has now spread worldwide. China, for example, has significantly expanded industrial sheep and goat production units, mostly for meat purposes, since the 1990s [1].

Currently, traditional large grazing systems coexist with enhanced supervision approaches, mostly employing indigenous rural breeds. The long-term viability of sheep and goat collection depends on the effective management of interconnected monetary, societal and environmental elements [2]. To enhance yield in a regulated environment, intensive and semi-intensive, agricultural methods demand significant investment. The basis for an effective production system comprises propagative, dietary, and group health supervision. Feedstuff sequences with excellent energy efficiency suitable for production are used to grow genetically modified breeds. Supported procreant technologies enable fast heritable advancement, allowing milk production throughout the year, reducing reproductive phases, and improving fertility and prolificacy depending on the production goal. Controlling biological, physiological and chemical harms and ensuring proper sanitary conditions in the flocks allows for high meat and milk production levels.

However, the expansion of production continues to bring new issues in preventing viral and parasitic attacks and managing endangered animals [3]. Disease risks are influenced by environmental variables, *e.g.*, biological pressures, large populations in restricted grazing and un-grazing systems, and habitat appearances [4]. Small ruminants' capability to minimize environmental restrictions and preserve fertile and prolific activities is linked with biological homeostasis. Modifying genetic and nutritional characteristics and other elements of animal care can assist in maintaining resilience. This chapter focuses on identifying specific sheep and goat breeding objectives that reflect the economic priorities and expectations, as well as the potential of disease-free native inhabitants.

6.2. PRODUCTION AND SURVIVAL OF INDIGENOUS SHEEP AND GOATS

Small ruminants are particularly significant socioeconomically for people in underdeveloped countries regarding food, money, and other advantages (*i.e.*, cultural purposes, investments, and security against disasters). They may also supplement other livestock by exploiting available feed resources, such as wide ranges of grazing land where crop production is problematic. Small ruminants perform an essential function for humans during seasonal or unexpected food shortages by balancing energy and food crises. Smallholder farmers use indigenous sheep and goats for various purposes, including profit, meat, fertilizers, and stiff wool. They are also helpful in the case of crop failure. Sheep and goat production is necessary to fulfill the demands of ever-increasing humans. Exporting sheep and goats will help increase the household's earnings. However, some restrictions impact their production (*e.g.*, death, food shortage, and inadequate indigenous breed utilization). According to professionals, the output of indigenous sheep and goats might be increased by genetic enhancement and careful management.

The efficient protection, management, breed enhancement, and marketing of indigenous sheep and goats are dependent on their sustainable utilization. This includes extensive information on breed identity and their distinct phenotypic characterization and habitats. Such information can be obtained through characterization studies. Around the globe, genetic improvement and characterization of phenotypes in many countries have been made to save indigenous sheep and goats. However, breeding methods, programs, and procedures to implement protection with sustainable consumption are insufficient to fulfill the threat to food and nutrition security [5].

6.3. BREEDING PROGRAMS

To start a breeding program at the minor stage, a comprehensive awareness of animal husbandry and the breeding system is required. More significantly, the contribution of farmers from preparation to execution is recommended for breeding projects to be successful. Public participation strategies can be used to identify smallholder farmers' sheep breed standards and trait preferences.

6.3.1. Overview, Design Criteria, and Execution

Small ruminant breeding initiatives are frequently seen as a difficult process that necessitates high technical and organizational expertise. Animal breeding has traditionally been sponsored in industrialized nations where major government breeding programs have been undertaken. These projects, which include data collecting and processing and evaluating the best candidates for optimum breeding, are now largely administered and funded by farmer cooperatives. The requisite structure to carry out such initiatives is usually missing in developing nations; previous attempts to imitate developed-country models have mainly failed.

CHAPTER 7

Application of Biotechnology to Livestock Feed Improvement

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Abstract: Feed and nutrition play a crucial role in the quality and quantity of livestock production, both ruminants and non-ruminants. As a result, the supply of feedstuff resources has not met the needs of animal populations, which might lead to decreased performance, poorer health, increased erosion, and overgrazing, which would increase the number of livestock animals. To meet animal protein requirements, feed availability with a low price containing high quality is a big challenge for nutritionists in the future quality. Conventional methods were used to increase livestock improvements, including livestock diseases, management, nutrition, genetics and breeding that resulted in enhancing livestock production. Currently, these methods are no longer sustainable; modern techniques, especially biotechnology, are required for optimum productivity. Utilizing natural and organic resources, for controlling food-borne diseases, modern biotechnology techniques are needed to implement the bitterness of the livestock population, increasing food safety and reducing poverty for livestock farmers. Due to advances in livestock nutrition, there has been a focus on enhancing livestock requirements, to understand the demand and availability of the ingredients, and composition and formulating cost-effective diets with optimum nutrient availability.

Keywords: Essential oils, Livestock, Livestock, Nutritive, Ruminants.

7.1. INTRODUCTION

Feed and nutrition have very important inputs in livestock production systems, including ruminants and non-ruminants, on a quality and quantity basis. Thus, the availability of feedstuffs resources has not fulfilled the animal populations' requir-

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ement, which may result in decreasing performance, health and enhanced erosion and overgrazing, increasing the population of livestock animals [1].

Animal production and performance are affected by the improper feed quality and quantity offered to animals. By the increasing rate of world population year by year, estimated to be 6 to 8.3 billion in 2030, it is very important to sufficiently produce food for the increasing population rate of 1.1% annually with the available resources, especially in developing countries. To meet animal protein requirements, feed available at low prices containing high quality is a big challenge for nutritionists in the future quality. Conventional methods were used to increase livestock improvements, including livestock diseases, management, nutrition, genetics and breeding that enhanced livestock production. Currently, these methods are no longer sustainable; modern techniques, especially biotechnology, are required for optimum productivity. By utilizing natural and organic resources, for controlling food-borne diseases, modern biotechnology techniques are needed to implement the betterness of livestock population, increasing food safety and reducing poverty for livestock farmers. In addition, cultivation and feeding of genetically engineered crops for livestock in the last 15 years, there was observed a huge compositional equivalence and safety between genetically engineered crops and other natural resources. Due to advances in livestock nutrition, there has been a focus on enhancing livestock requirements understanding the demand and availability of the ingredients, and composition and formulating cost-effective diets with optimum nutrient availability [2]. Based on the species, age, and nutrient requirements for production purposes, livestock should be fed according to body nutrient requirements. The practical diets should be formulated according to the recommendations given dietary nutrients, including energy, protein, amino acids, essential fatty acids, minerals, and vitamins [3]. Biological techniques include recombinant rumen microbes, microbial feed enzymes, organic acids, bypass fat and proteins that can enhance the nutritional values of the forages used for livestock production.

Implementation of genetically engineered-based techniques has been enhanced for animal perfect balanced feeding and digestibility or to change the metabolic and digestive systems of animals to enable utilizing a feed. Enhancing the amino acid profile through genetically modified crops may be utilized to minimize nitrogen excretion in monogastric animals. The application of biotechnology to enhance the maximum nutrients digestibility and production, and the recent advanced techniques have been described in this chapter. The biotechnology application has played an important role in enhancing livestock production in developed countries to alleviate poverty and hunger, reduce disease threats, and secure environmentally friendly stability in developing countries. A wide range of biotechnology techniques has been used to enhance animal nutrition and production, breeding, genetics and health in developing countries. To enhance digestibility and availability of nutrients, particularly essential amino acids or complete proteins, fermentation techniques are used. By using silage inoculants, there have been reports of enhanced good-quality silage and improved milk production in livestock animals.

A major part of animal feeds consists of multiple fibrous digestibility levels and nutritional values. Animal nutrition scientists reported the advancement of the nutritional values for the meal to boost digestibility and reduce anti-nutritional factors from ruminant meals through using biotechnology. The most recent advances in biotechnology are the gut microbiota that utilizes nutrients to produce the organic acids and microbial proteins to enhance milk production and animal body health. This can be done by introducing biotechnology products in the gut ecosystem to enhance the growth of beneficial microbes, and genetically modified beneficial microbe's production to enhance the capacity of specific functions in the healthy gut. These microbes have the potential to break down lignin and fibrous portions of forage, toxin degradation, and essential amino acid metabolism to lowering methane gas production, or to colonize new microbial communities in the healthy rumen to enhance the feedstuff digestibility.

7.2. ESSENTIAL OILS (EOs)

Essential oils are a mixture of volatile and fragrant compounds derived from plants and are named with aromatized plant characteristics. EOs are the volatile and non-volatile compounds mixture that is produced by plants as secondary metabolic pathways for the protection against external agents (herbivores and pollinators) and environmental stresses (high temperature, ultraviolet lights) [4]. Essential oils can be utilized as feed additives and growth promotors in production systems, including broilers and livestock. Scientists reported the positive outcome of the dietary EOs on feed efficiency, ideal body scoring for milk production body and better growth performance in broilers and livestock in forms of single or mixture. These are present for possessing antimicrobial activity and also shown anti-inflammatory, antioxidant, emulsification and lipid-lowering activities.

EOs are utilized in the form of a blend as a single or along with combinations of plants rich in amino acids. These betaines play important osmolar and metabolic activities and enhance the durability of raw feed materials to boost animal health and productive performance. There are multiple beneficial antioxidant effects *in situ* that are reported to enhance the durability of feed as well as to enhance the meat quality, decreasing lipid oxidation of feed [5]. Betaine produced from different plants, is a simple and important proteinogenic amino acid that enhances

CHAPTER 8

Sensing of Nutrients and the State of Sensors for the mTORC1 Pathway that are Controlled by Amino Acids

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Abstract: The mechanistic target of rapamycin (mTORC1) is an expert cell production controller which reacts to a different set of natural information sources, such as amino acids. Various proteins have been differentiated recently to help communicate amino acid accessibility to mTORC1. Rag guanosine triphosphatases (GTPases) transfer amino acid accessibility to the mTORC1 duct, and the mTORC1 apprentice to the amino acid on the Lysosome in a conventional manner. Later on, several sensors were exposed for the amino acid-reinforced mTORC1 pathway, including Leucine, Argina, and S-adenosyl methionine. The representation of these sensors is essential to explain why cells change the pathways of amino acid detection requirements. Here, we survey these new advances and feature the assortment of further inquiries that rise out of the recognizable proof of these sensors.

Keywords: Amino acid, Lysosome, mTORC1, Rag GTPases, Sensor.

8.1. INTRODUCTION

Rapa Nui, a small South Pacific island, was visited by a group of Canadians (also known as Easter Island). They conducted a series of soil experiments in 1964 to discover novel antimicrobial agents [1]. In one of these samples, Sehgal and colleagues isolated bacteria with antifungal, immunosuppressive, and antitumor properties [1]. The drug rapamycin, also known as sirolimus in medical parlance, is named on its discovery's location. In corresponding with endeavors to distinguish the target of rapamycin, numerous research centers attempt to comprehend its capacity by concentrating on; why rapamycin represses the

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proliferation of cells [2]. Early research in the Candida albicans pathogenic yeast mechanism of rapamycin toxicity has shown [2] that this rapamycin suppresses numerous metabolic processes, including the synthesis of proteins [3]. Ensuing work in human cells by many researchers [2] have shown in their studies that rapamycin reduces S6 phosphorylation of ribosomal protein and starts mRNA translation [2], building mTOR as a focal controller for cell-level anabolic metabolism and mass amassing [1, 2, 4]. Rapamycin has been found to inhibit the secondary effect of reduced protein synthesis and development; hence, the cell size of the cell cycle was independently controlled by mTOR, as previously believed. Shortly after, Hall observed that despite rapamycin's unsatisfactory state for yeast, it does not reduce cell size by inhibiting mRNA translation or growth. Hall found that rapamycin's effects on yeast growth could be replicated by inhibiting TOR1; As a main growth regulator and a temperature-sensitive allele, the TOR1 gene product has been under intense scrutiny.In animals, evidence relating to the rapamycin growth pathway targeting the *Drosophila melanogaster* fruit fly came first from genetic studies. These indicated that flies with decreased dTOR are more diminutive, remarkably as cell size is reduced and not cell number [4]. Additional research in mice confirmed mTOR's role as a key regulator of mammalian cell organ and organ size, particularly in a work conducted in collaboration with Andrew S. Peterson [2]. Other laboratories have developed mTOR [1].

Evolutionally preserved the robotic objective rapamycin complex 1 (mTORC1] from yeast to mammals [5] goes about as a focal flagging center point that incorporates supplements, development elements, and the power to regulate cell growth and digestion *via* various anabolic and catabolic cycles [1, 4, 5]. Rheb and Rag GTPases, which sit on the surface of lysosomes due to environmental stimuli, promote mTORC1 activation [6]. Many of these sources of information, including the factors such as growth, cell stress, and energy, were involved in the invasion of the TSC complex by TSC1, TSC2, and TBC1D7, a GTPase-initiating protein (GAP) for Rheb [6]. In this manner, a yeast homolog Pinnacle protein that is closely linked to FKBP12-rapamycin in a warm-blooded animal was found. This protein is referred to as rapamycin and FKBP12 target1, and both of these proteins are FKBP12-rapamycin-related proteins [5, 7-10]. Early studies have shown an association between mTOR activity and ribosomal protein S6 kinase 1 (S6K1] activation, as well as 4E-binding protein 1 [4EBP1] phosphorylation, controlled by amino acids [5]. Nevertheless, even modest changes in amino acid adequacy or rapamycin failed to alter mTOR signaling, suggesting that its functions may be more complex [5]. Much later, the KICSTOR complex (representing mTORC1 controllers KPTN, ITFG2, C12orf66, and SZT2] was recognized as a GATOR1 platform on the lysosomal surface [6] (Fig. **1**). Deregulation of mTORC1 occurs routinely in pathophysiology conditions, particularly in malignant growth [5]. The rapamycin (TOR) gene target was initially recognized in rapamycin-impermeable yeast that binds to peptidyl-prolyl isomerase FKBP12[5]. Up to this point, most of the nutrient-sensing pathway members described the ability to easily balance the effect of the nuclear localization state of Rag GTPases on the movement of nucleotide through the pathway; the amino acid sensors, notwithstanding, stayed tricky [6].

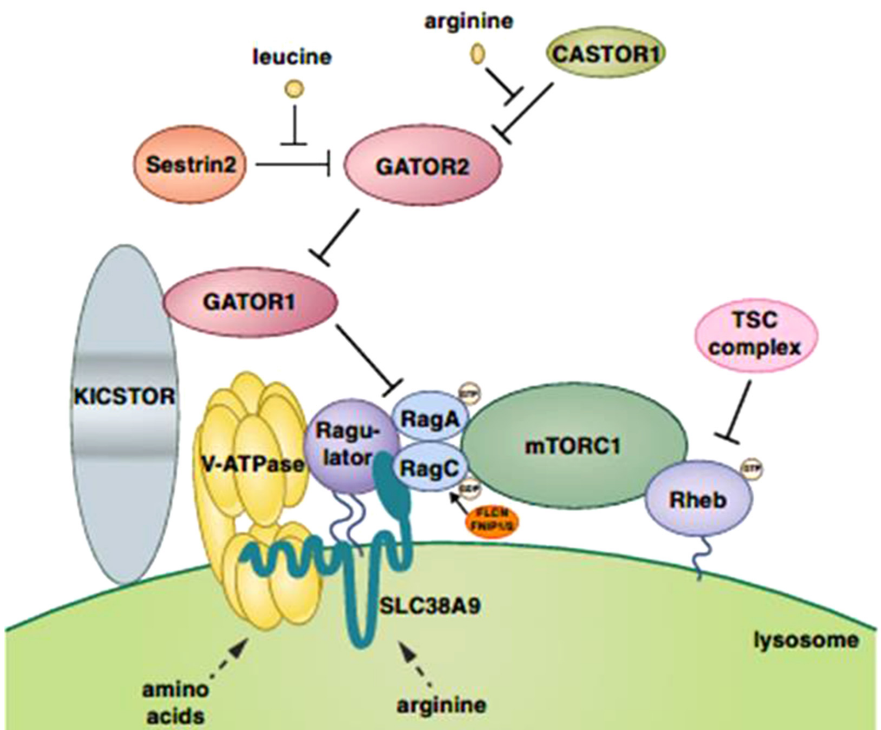

Fig. (1). 1 This schematic represents the key molecules upstream of mTORC1 in the nutrient-sensing pathway. Adopted [6].

8.2. REGULATION OF mTORC1 SIGNALLING PATHWAYS

8.2.1. Membrane of the Plasma

Plasma film carriers of amino acids responsible for trade in amino acids between extracellular and intracellular microenvironments assume a part in the guideline of mTORC1 movement [5]. For mTORC1 activation, the family of solute carriers that carry glutamine with remarkable efficiency (SLC) 1 member 5 (SLC1A5] is needed [5]. SLC7A5, a member of the SLC3A2 dehydrogenase family, forms a

CHAPTER 9

Genome to Phenome: Improving Animal Health, Production, and Well-Being

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Abstract: The improvement of animal health can be achieved through variations in local and regional conditions (*e.g.*, altitude). In addition to biotic stress, abiotic stresses include changes in the temperature, illnesses, pests, and enhancing biotic stress. Effective farm animals must maintain fitness as one of their main responsibilities. As the demand for animal protein, resistance to the previous drug, and the drive to reduce antibiotic use in agriculture grow, this task will only become more difficult. The susceptibility to all disorders may differ genetically, but the variation has not yet been fully utilized. It is difficult and costly to measure this alteration in part because it is difficult and expensive. Therefore, genomics can contribute to the refinement of animal fitness. In this chapter, we will examine the concept of resistance, variation in susceptibility, and elasticity, as well as provide examples, present a few of the most recent developments in livestock and pigs, and briefly discuss the application of gene enhancement to addressing disorder resistance. Ensure clients can select from conventional meals, healthy choices (lean meats), dietary improvements, and food raised using preferred farming practices (natural, without antibiotics).

Keywords: Genomic Tools, Infectious pancreatic necrosis (IPN), Phenome.

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9.1. INTRODUCTION

The word "genome to phenome" explains the association and causality between the genome of an animal and its physical traits, phenotypes, or the noticeable physical or physiological developments or traits (phenome) [1] This knowledge is necessary to comprehensively understand the genetic and environmental factors that affect animal productivity. By understanding these factors, researchers can develop strategies to improve overall performance by furthering the animal's genetic potential or by optimizing the environment in which the animal is raised. The field of animal genomics is currently devoted to sequencing animal genomes and identifying their genes, after which genomic variation is used to select for expected genetic variations in regularly measured characteristics [2] Primarily, finding genotypic records changed into the main undertaking; though, over the past decade, researchers, producers, and enterprise partners have been particularly a hit at collecting a big amount of genotypic and phenotypic statistics from massive numbers of animals. This data has been instrumental in identifying key genotypic and phenotypic traits that have been useful in developing successful production and enterprise strategies in the last decade [3]. Further tasks can be preserved to minimize costs and growth of the overall performance of those genotyping systems, especially in industries in which the financial cost compared to genotyping prices, the cost of an animal is low. Though, for plenty of agriculture applicable in terms of species, our current mission is to accept an animal's phenotype based on its Genotype and environment [4]. Gene-modified knowledge, which will permit the examination of identifying remaining and novel genetic variations, will enable fundamental genetic variations. It is important to note that genomic possessions are now restricted by phenotypes collected. It is important to consider that genomic possessions are now restricted by phenotypes that might be collected. With the effective use of variety and amendment of the genomes of animals to appropriately change their phenome, in-depth knowledge of natural genome science should be developed to have a greater capacity to symbolize and grade phenomes with greater intensity. Much of this information blueprint is directed closer to this reason [1].

9.2. CHALLENGES AT CURRENT

9.2.1. Health Challenges

Agricultural animals have helped to meet the human nutritional needs for food and fibers. They account for 18% of overall calorie consumption and 39% of protein consumption (Food and Agriculture Organization of the United Nations [FAO], 20 18] [5]. Animal by-products are used in a variety of applications, including medicinal, cosmetic, domestic, and industry, in addition to food (Economic Research Service and USDA, 2011] [6]. Endemic infectious diseases pose unique problems since they are diseases for which standard disease management measures have failed due to their endemic status. Tick and nematode infestations are two examples of global relevance, with widespread acarida and anthelmintic resistance, respectively [7]. As a result, complementary management measures are necessary, and one such approach is breeding for enhanced host resistance to infection or illness. Because of the heterogeneity in host immunological responses to infection, there is always genetic variance in disease resistance among hosts [8]. Animals are chosen for their increased production, which will raise the producer's profitability. Health characteristics were not taken into consideration in this situation. As a result, animals with higher productivity and a shorter productive life were chosen. Furthermore, the intensive livestock production system has pushed animals to be exposed to larger pathogen loads, making them more susceptible to illness. Infectious disorders are caused by microorganisms that infect and colonize the host, disrupting physiological functioning and threatening animal welfare and productivity. Diseases are still the leading source of economic losses in the animal business, even with the finest management measures (Genomic Tools and Animal Health) [9].

In basic words, genomic breeding is the use of deoxyribonucleic acid (DNA) or genomic information to choose superior animals and make them the parents of the following generation [10]. Thus, genomic selection is essentially the process of using genetic information to make decisions based on genetic differences (*e.g.*, milk supply, body the weight of the eggs, the egg size, *etc*.) considered in the selection for increased productivity (*e.g.*, litter size, milk yield, *etc*.). In the previous nine decades, rapid increases in cattle qualities have been achieved thanks to the use of using quantitative genetic theories, statistical techniques, artificial insemination, and structured breeding procedures [11] (Fig. **1**). The actual processes behind these improvements were mostly unknown. However, the understanding of the relationship between DNA variants and animal qualities emerged with the discovery of DNA structure. This was followed by advances in DNA sequencing and genotyping tools [12]. As a result, the Animal Breeding Act was required to include genetic information. This was in an effort to speed up the reaction and boost production as demand for animal products increased due to an ever-growing population and changing social needs. One of the greatest case studies of the application of genome-based technology to an infectious livestock illness and one of the earliest deployments of DNA-based selection is the salmon viral disease infectious pancreatic necrosis (IPN) [13]. As explained below, parallel and contemporaneous research projects in Norway and Scotland came up with nearly identical conclusions. Each study validated the other. The researcher's findings are now routinely integrated into the breeding strategies of the two

CHAPTER 10

Monitoring Animal Behavior and Control Using Wireless Sensor Technologies

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Abstract: The constantly rising need for dairy productivity farm automation is a key concern in today's world. A necessity for technology that would result in lower costs and labor inputs while increasing agricultural output exists, and cattle health monitoring should be given top attention to achieve this requirement. Remote monitoring of animal behavior in the environment can aid in managing both the animal and the animal's influence on the environment. Geographical positioning systems (GPS) collars that record animal whereabouts with high temporal frequency enable researchers to study animal behaviour and environmental interactions. This paper has discussed how to track and control animals using wireless detector strategies. For a long time, the only mode to track wildlife was to objectively check and notice the program and habits of a beast and set a label on it, and optimism that eventually that same beast would be recalled. But that's not sufficient to study the performance of animals. The study and nursing of animals have always been a subject of great curiosity, but studying the behavior of animals is a tough task due to the problems of shadowing and classifying their action. Currently, technology allows designing WSN, making these tasks easier to carry out. Studying the conditioning of wild animals is grueling due to the difficulties of shadowing and classifying their conduct. In this work, we have discussed the behavioral and hierarchical wireless detector network mounted in the demesne to collect information about beast behavior using a device enforced on them. Tracking is one of the most effective ways; with minimum trouble and lower charges, we get a detailed position or movements of similar animals through GPS on a daily basis through computer data.

Keywords: Animal, GPS, Livestock, Sensor technology, Tracking.

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10.1. INTRODUCTION

Monitoring animal behavior and connecting it with environmental data to establish effective management intervention tactics might help reduce the environmental impact of animals [1]. However, monitoring is made more difficult by the necessity to record animal movement with landscape conditions, which alters animal behavior [2]. A Wireless Sensor is a gadget that monitors a physical change in the physical terrain and can wirelessly send that data to another location [3]. A wireless detector network comprises a collection of detectors, each having its power, wireless communication, data storage, and processing capabilities [4]. Data from any knot may be sent back to the gateway knot and even to the internet through communication between detector bumps. Bedded bias networks that work together to provide greater monitoring across geographical and temporal scales are becoming increasingly popular [5]. Ecologists and environmental scientists increasingly use wireless sensor networks in terrestrial-monitoring operations to gather and send data from remote field sites back to base, where each knot often has numerous sensors to detect different environmental factors [6]. Within WSN, there have also been some recent examples of WSN bumps being fitted to brutes, resulting in a collection of mobile bumps. Communication across comparable networks of movable bumps provides a unique set of obstacles in the vast natural landscape [7]. The operation of wireless detector networks in which a detector is mounted to a beast's body so that its position, position, and transportation may be linked is known as beast shadowing. Wireless detector networks provide an animal's complaint viewpoint. Stress, as well as the presence of contagions and infections, are detected by detectors. According to data collected by these detectors, individuals and communities travel within original locations, resettle across abysses, and resettle across major lands [8].

Wireless detector networks have been widely employed in various applications, most notably in husbandry and niche monitoring. Environment monitoring has evolved into a critical sector of control and protection, allowing for real-time system and control connection with the physical environment [9]. The memory is primarily utilized as a data storage facility, whereas the transmitter performs both transmitter and receiver functions. Detector bumps will connect and wirelessly relay the reused data to the Gomorrah knot. The Gomorrah knot takes data from all of the bumps and sends it to the stoner through the internet, anatomized [10]. Since roughly 1900, when the first raspberry ringing or banding systems were launched, scientists have been completely individual beast movement. Experimenters began using radio transmitters to follow wildlife in the late 1950s. The Argos satellite system introduced a new way of tracking organisms encyclopedically in the late 1970s. The global positioning system (GPS) began to provide the possibility of obtaining high-resolution shadowing data in the early

1990s [11]. Better communication methods, smaller battery sizes, and other technological advancements have resulted in various tracking approaches throughout the twentieth century. There are the following types of famous wireless sensors. Terrestrial WSNS, Underground WSNS, Underwater WSNS, Multimedia WSNS and Mobile WSNS.

10.2. ANIMAL TRACKING

Data helps us to understand how individualities and populations move within original areas, resettle across abysses and mainlands, and evolve across generations. Beast shadowing is the operation of wireless detectors in which a detector is attached to creatures' bodies so that the transportation and position of creatures can be linked. Gives different beast shadowing and monitoring using wireless detector networks. The paper provides a design to detect cattle grazing using a wireless detector network. The paper proposes and studies a wireless detector network-grounded system for general target beast shadowing like beast shadowing in the near area of foliage and fauna passages erected to set up secure habits for creatures to cross transportation structures (Fig. **1**).

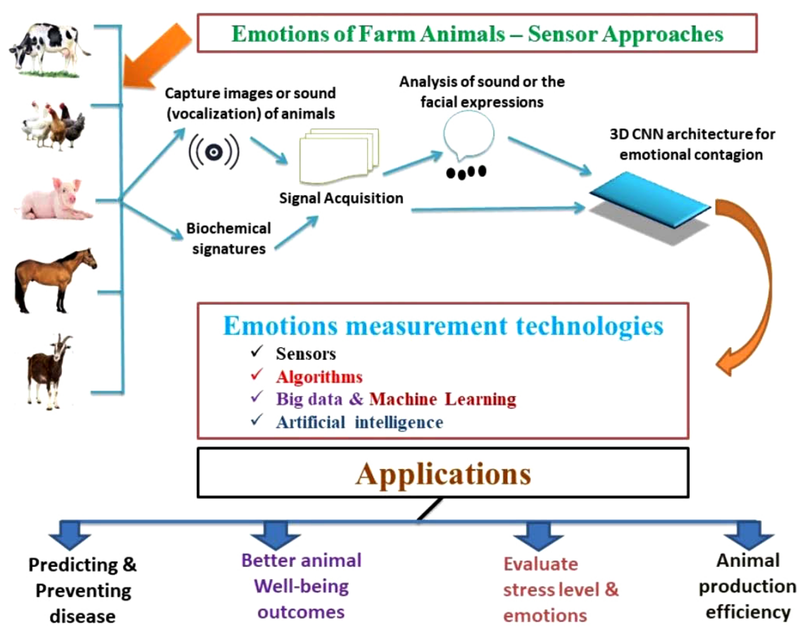

Fig. (1). Emotions of farm animals- a sensor-based approach [12].

CHAPTER 11

Use of Artificial Intelligence in Assessing the Livestock Management

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Abstract: In the livestock sector, artificial intelligence is crucial. The livestock business needs to make improvements to artificial intelligence right away. With the aid of artificial intelligence, livestock farms will be able to make the processes automatic with reduced major costs and an improvement in the quality of livestock products. Artificial intelligence assists livestock farms in gathering data and performing analysis accurately according to consumer behaviour prediction, such as buying patterns, leading trends, *etc*. The livestock business will undergo significant upheaval thanks to artificial intelligence. Many dairy farms and local farmers utilize animal feed without considering how it will affect the milk and the animals. AI use will undoubtedly significantly impact the quality of the forage and the animals' way of life as AI is increasingly widely used and accessible. Most dairy sector activities will be automated, and data about past farm operations will be generated. Farmers are now turning to smarter approaches to help regulate the right use of land, water, and energy needed to feed the world's population and alleviate the global food problem in response to the expanding population. By utilizing machinery and monitoring systems, AI technology has changed farming and cattle-related businesses.

Keywords: Artificial intelligence, Computerized twin, Livestock management, Programmed self-learning component.

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11.1. INTRODUCTION

Artificial intelligence plays an important role in the livestock industry. Artificial intelligence is a technology that needs immediate changes in the livestock industry [1]. Artificial intelligence helps livestock farms to collect data and perform analysis accurately according to the prediction of consumer behavior like buying patterns, leading trends, *etc*. with the help of artificial intelligence; livestock farms will be enabled to make the processes automatic with reduced major cost and with the improvement in the quality of livestock products [2].

Artificial intelligence will bring great change to the livestock industry. Local farmers and many dairy farms use fodder for animals without knowing its impact on the milk and animals. With AI, changes in the fodder quality and lifestyle of the animals will definitely have a great impact and its quality as AI is becoming more common and easily available [3]. The dairy industry will automate most of its processes and product information relating to the farm's operational history [4]. With a growing population, the farmers are now moving towards smarter techniques that can help regulate the proper usage of land, water and the energy needed to feed the planet and hail the global food crisis. AI technology has revolutionized the future of livestock industries and also revolutionized the future of farming by using machines and monitoring systems [5]. Fig. (**1**) shows the role of sensors, big data and machine learning in modern animal farming.

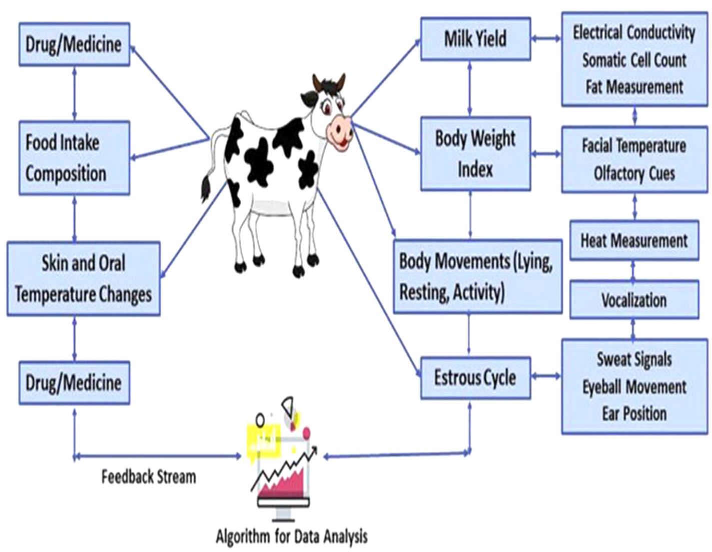

Fig. (1). The role of sensors, big data and machine learning in modern animal farming [6].

11.2. EMOTION AND AFFECTIVE STATES

Feelings or emotional states acknowledgment in livestock is an underexplored research space. Notwithstanding critical advances in the creature government assistance research, the creature is full of feelings figuring through the turn of events and utilising gadgets and stages that can perceive as well as decipher and deal with the feelings in the early stage. By exploiting the gigantic capability of biometric sensors, computerized reasoning empowered enormous information techniques, significantly ing headway of creature government assistance principles and meeting the earnest need of overseers to answer to keep up with the prosperity of their creatures. Livestock, numbering more than 70 billion worldwide, are progressively overseen in huge scope, serious homesteads. With public mindfulness and logical proof developing that livestock experience enduring, as well as full of feeling states, for example, dread, dissatisfaction and misery, there is a dire need to foster effective and precise techniques for checking their government assistance. Currently, there are no logically approved 'benchmarks' for evaluating transient enthusiastic (emotional) states in livestock, no settled proportions of good government assistance, just marks of unfortunate government assistance, like injury, agony and dread. Traditional ways to deal with checking animals for government assistance are tedious, hinder cultivating processes and include emotional decisions. Biometric sensor information empowered by Artificial Intelligence is an arising savvy answer for subtly observing animals. However, their true capacity for evaluating emotional states and pivotal arrangements in their application is yet to be understood. This survey gives imaginative strategies for gathering enormous information on livestock feelings, which can be used to prepare man-made brainpower models to arrange, evaluate and anticipate emotional states in individual pigs and cows. Stretching out this to the gathering level, informal organization investigation can be applied to display enthusiastic elements and disease among creatures. At long last, 'computerized twins' of creatures fit for continuously reenacting and foreseeing their emotional states and behavior are a close-term plausibility [7]. Fig. (**2**) shows e role of artificial intelligence in sensing animal emotions in modern animal farming.

CHAPTER 12

Next-generation Sequencing in Veterinary Medicine Technologies to Improve Diagnosis, Control, and Management of Livestock Diseases

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Abstract: Next-generation sequencing has changed the study of genetics. NGS technology is predicted to be significant in veterinary care and animal husbandry. With the development of modern techniques, genomes can now be sequenced considerably more quickly and accurately. In the current review, we detail the many sequencing techniques that are accessible and also go over a few biological topics where using next-generation sequencing might lead to whole new directions in veterinary research. Large volumes of genomic, transcriptomic, and proteomic data may now be analysed by researchers thanks to the advent of high throughput molecular technologies and accompanying bioinformatics. The volume of DNA sequence information that can be generated using Next Generation Sequencing (NGS) technology is a glaring illustration of this stage. The identification and quantification of proteins in a given sample have also been made easier by recent advancements in high-precision mass spectrometry and protein and peptide separation efficiency. The way biological and evolutionary processes are investigated at the molecular level is beginning to change due to these technological advancements, which are also being utilised to research infectious illnesses in animals. To better understand how next-generation sequencing functions and how it might be applied to veterinary medicine for the sake of disease management and control, this chapter focuses on presenting existing and projected insights.

Keywords: Animals, Bioinformatics, Diseases, Infectious, Next-generation sequencing (NGS), Veterinary.

12.1. INTRODUCTION

DNA sequencing is a breakthrough in veterinary medicine that significantly improves the management, diagnosis, and control of livestock-associated infe-

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ctious diseases. During the advancement, Sanger's dideoxy or “chain-termination” approach changed the DNA sequencing technology [1], later named first-generation sequencing. Techniques like recombinant DNA technology and polymerase chain reaction (PCR) supported the genomics revolution by giving away to generate large quantities of pure DNA species necessary for sequencing. However, the major drawbacks of first-generation sequencing include lack of automation, the complexity of the procedure, introduction of thermostable DNA polymerases, difficulty in interpreting the sequences, florescent dye-labeled dideoxynucleotides, and capillary sequencing. After decades, a new technology known as pyro sequencing was discovered, which served as the foundation for an advanced sequencing approach termed as “Next-Generation Sequencing”.

Recent developments in nucleic acid sequencing technology, “next-generation” sequencing (NGS), have transformed and opened up a new era of diagnostic and research applications. NGS, one of the most distinguishing characteristics, includes low-cost, high throughput and processing hundreds of gigabases of sequence in a single run. In veterinary medicine and animal husbandry, NGS technology is anticipated to play a significant role in genomics, proteomics, transcriptomics, and routine diagnostic tests. With the introduction of improved techniques, it is now feasible to sequence genomes at a considerably quicker rate and with better precision.

In veterinary medicine, the exact genetic identification of pathogens should no longer be overlooked for monitoring, diagnosing, and preventing infectious illnesses [2]. Indeed, the number of pathogen-specific molecular markers with proven diagnostic or prognostic value quickly expands, making analysis more comprehensive and useful. Despite globalization, infectious diseases have compelled diagnostic laboratories to rise to the challenge of being at the forefront of research and technology to identify genetic markers and novel infections responsible for various virulence phenotypes.

In this circumstance, the introduction of next-generation sequencing (NGS) has provided an exceptional opportunity to collect high-throughput sequence data with or without prior knowledge of the targeted pathogen. For these reasons, NGS is the preferred diagnostic technique for many laboratories and is also frequently utilized in veterinary medicine [3]. Despite the undeniable benefits of this technology, the NGS test has a variety of working procedures (preparation of the sample, enrichment of tissue, isolation of nucleic acid, preparation of library, grouping and quantification, sequencing through unique chemical methods, data analysis). It is thus subject to mistakes, as shown in Fig. (**1**). In particular, the considerable amounts of raw data that arise require a complex bioinformatics analysis, which is excellent computing power for obtaining information about the sequenced samples. As a result, the bioinformatics analysis looks particularly susceptible, requiring adequate quality controls to ensure the results are reliable [4].

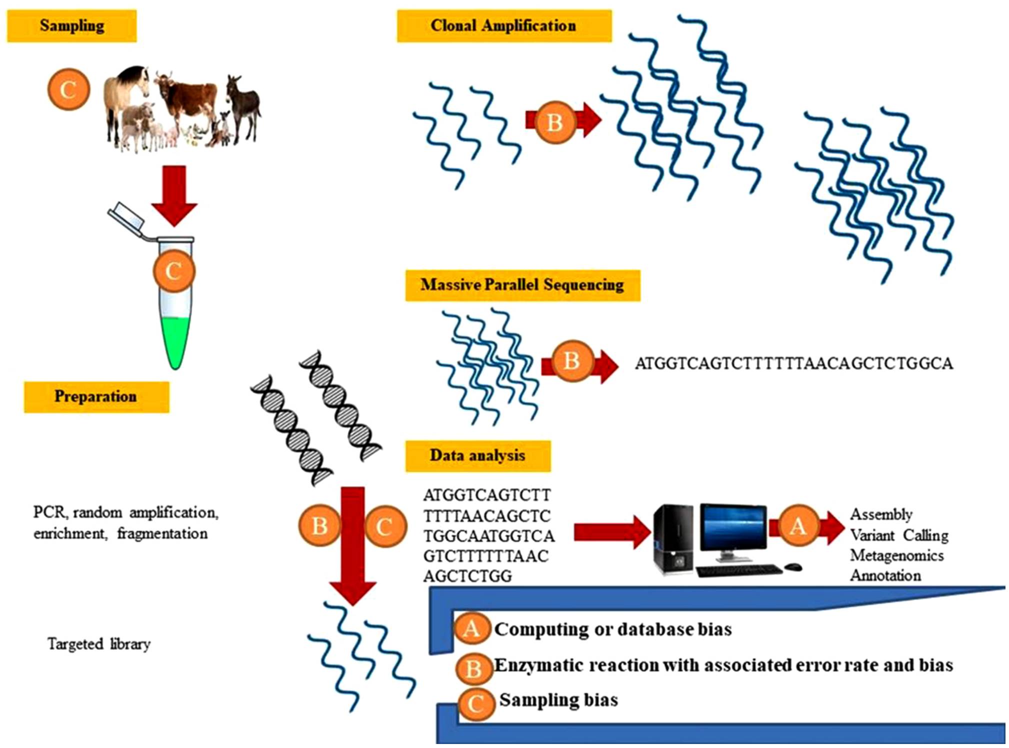

Fig. (1). Steps in next-generation sequencing and data analysis workflows where error and bias introduction may occur.

The NGS phases can be categorized into three main phases, which include primary, secondary, and tertiary [5]. The translation of raw signals into base calls and sequence reads is usually done directly in the sequencing platform during the primary analysis. The conversion is done using device-integrated software, and the collected information is demultiplexed if necessary, such as assigning the measured values to the appropriate sample. Raw data refers to the output of the machine sequencer, which is the outcome of the primary analysis. The secondary analysis includes a) filter procedures to eliminate inaccurate data; b) compilation of high-quality measured values, both from a reference and a *de novo* method; and c) recognition of variations, depending on the kind of sample and the study aims. A tertiary analysis is a human-led interpretation of sequencing data mostly

CHAPTER 13

Use of Genomics in the Diagnosis and Treatment of Livestock and Animal Diseases

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Abstract: The use of biotechnology has proved to be a key factor in handling different livestock problems. Many issues have proved to be silent killers, and their appropriate diagnosis and treatment are the need of the hour. Advancement in biotechnology and genomics is being used in preventive and clinical medicine, production of recombinant biotechnology-derived vaccines, molecular gene cloning, application of polymerase chain reaction (PCR), Polymerase chain reaction-restriction fragment length polymorphism (PCR-RFLP), Real-time polymerase chain reaction (RT-PCR), gene therapy and many more. This chapter will cover the use of genomics and biotechnology in veterinary medicine.

Keywords: Diagnosis, Genomics, Livestock, Treatment.

13.1. INTRODUCTION

Animal diseases cause billions of losses to relevant industries, including production and reproduction losses and severe zoonotic diseases. Genomics can be used for the timely and rapid diagnosis of animal diseases, and advancement in technologies is also being used to treat different problems.

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The discovery of DNA by Watson and Crick revolutionized the field of human and animal genomics [1]. The application and use of genetics and genomics to diagnose veterinary diseases have previously been mentioned [2]. Functional and comparative genomics and proteomics have provided effective approaches and guidelines in identifying the environmental and genetic factors responsible for many complex diseases and developing novel prevention and treatment strategies [3].

Gene cloning is playing an important role in veterinary health. Various procedures have been discovered for separating plasmid from the bacterial cell and then incorporating external DNA from another source into that plasmid. After that, the plasmid is reintroduced into the bacterial cell. As a result, that recombinant plasmid replicates along with the old pattern plasmid. It is analyzed that the gene and gene product interact complexly to combat the disease situation [4]. The analysis of networks of genes and disease describes the mechanism by which gene networks and protein nodes interact and combat the disease. In veterinary genetics, we consider those principles appropriate to animal production and animal diseases [5]. The genetic diseases in animals are more difficult to diagnose, treat and cure, as all other types of infectious diseases are controlled by various typical applications of vaccination, antibiotic, and sanitation programs. So now most animal populations are dying because of genetic diseases, especially those that have late onset [6].

This chapter reviewed the available techniques in genomics for the diagnosis and treatment, and even prevention of veterinary-related issues and diseases.

13.2. IMPORTANCE OF GENETICS IN DISEASE DIAGNOSIS

In the last few years, diseases of genetic origin have gained importance as the prevalence and risk of infectious diseases have minimized due to better preventive strategies (vaccination), treatment options, and sanitary measures. Genomics has become the talk of the town in veterinary research. Diagnosis of genes responsible for genetic diseases is really important as:

1. Genetics is the base for all diseases [7]

2. Biochemical bases of diseases are identified with the help of gene identification, thus helping in designing suitable therapy [8].

3. Gene therapy can only be carried out after the identification of defective genes.

4. Genetic defects in the form of gene mutation are identified and used to screen individuals with defective genes [8].

Identification of carrier animals is important to reduce the risk of disease. Once the gene responsible for the genetic disorder is identified, it is easy to develop diagnostic tests to identify populations with defective genes.

13.3. ASSOCIATION OF GENETICS AND ANIMAL DISEASES

The role of genetics in animal disease diagnosis was highlighted in 1989 by Hauge. Genome sequencing has revolutionized the diagnosis of genetic diseases. Following diseases will highlight the association.

13.3.1. DUMPS (Deficiency of Uridine Monophosphate Synthase)

DUMPS is an autosomal recessive disorder of Holstein cattle that causes early embryonic loss in homozygous calves due to low levels of enzymes and elevated levels of orotic acid. The genetic evaluation revealed that DUMPS is due to mutation in the gene carrying information for enzymes and point mutation revealed by genetic evaluation of HF pedigree [2].

13.3.2. Citrullinemia

Citrullinemia is the first genetic disease diagnosed in Australian Fresian cattle with the aid of DNA testing [2]. Genes responsible for argininosuccinate synthetase enzyme were isolated and sequenced by Dennis *et al.* in 1989 using rats.

13.3.3. MSUD (Marple Syrup Urine Disease)

Affects polled cattle of Australia and Humans due to mutation in the gene responsible for branched chain alpha Ketoacid Dehydrogenase enzyme, one of the mitochondrial enzymes involved in the process of oxidative Decarboxylation [2].

13.3.4. HYPP (Hyperkalemic Periodic Paralysis)

The disease causes paralysis in Quarter horses after the ingestion of potassium associated with the point mutation in the skeletal muscle gene. The same genetic defect is observed in humans with a mutation in sodium channel skeletal muscle genes [2].

CHAPTER 14

Role of Recombinant Vaccine in Livestock

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Abstract: A lot of diseases affect animals which need treatment. Antibiotics and other drugs have been widely used in the treatment. Drug residues in milk and meat are the main issues and pose health risks to humans. A vaccine is the only solution to keep animal products safer from drug residues. Modern veterinary vaccine history started in the 19th century when Edward Jenner used antigens from cowpox pustules. A vaccine is a weakened organism or part of an organism that is given to animals to produce immunity by the body. Soon after the development of vaccines, safety issue arises. Especially live attenuated vaccine was a matter of concern as it may revert to cause disease. Nowadays, most of the livestock vaccines are live attenuated or killed. Vaccines have been developing against bacteria, viruses and parasites also. Animal-origin products are also contaminated with parasite infection and are a source of infection to other animals and humans. Parasites usually stay in the gastrointestinal tract of animals, and oocytes are disseminated through feces into the environment, which are transmitted to other animals. Vaccines are cost-effective methods to prevent diseases in animals and humans. It not only enhances animal meat and milk production but also saves humans from zoonotic diseases. Without vaccines against major animal

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diseases, it will not be possible to feed 7 billion people with proteins. Zoonotic diseases, such as brucellosis and Leptospirosis, will be more prevalent in the world without the vaccination of animals. Rinderpest is almost eradicated from the globe and will be the second disease after smallpox which is diminished through proper vaccination and surveillance.

Keywords: Immunity, Recombinant vaccine, Subunit vaccine.

14.1. INTRODUCTION

Livestock is always the backbone of a country's food chain. Food animals provide a major part of protein and other food ingredients for human needs. It is important to keep food animals healthy for well beings of themselves and human health. Many diseases are found in animals which need treatment. Antibiotics and antivirals are commonly used to treat these diseases. Drug residues in milk and meat can cause harm to humans. For this, vaccine is the only option to prevent animal diseases. In the 19th century, Edward Jenner used antigens from cowpox pustules. A vaccine is a weakened organism or part of an organism inoculated into animals which provide immunity to the body. Live attenuated vaccine was a matter of concern as it may revert to cause disease. Nowadays, many live attenuated or killed vaccines are used in livestock. Vaccines have been made against bacteria, virus and parasites to provide resistance against them. Animal origin products contaminated with parasite infection are a source of infection sin other animals and humans [1]. Parasites usually reside in the GIT of animals and oocytes disseminate through feces into environment. It is the source of transmission to other animals. Vaccine is one of the cost-effective methods to prevent diseases in animals and humans. It not only increases animal meat and milk production but also protects humans from zoonotic diseases. Zoonotic diseases such as brucellosis and Leptospirosis will be more prevalent in the world without the vaccination of animals. Rinderpest is almost eradicated from the world and will be the second disease after smallpox which is diminished through proper vaccination and surveillance. Rabies, also one of the fatal zoonotic diseases, has been eradicated from humans in most developed countries due to the vaccination of domestic animals. However, in Asian and African countries, 98% of human rabies cases are because of unvaccinated dog bites. Food borne diseases risk has been reduced by vaccine development against *E. coli* O157:H7 and Salmonella in food animals. These vaccines reduce shedding of pathogens from animals. Vaccines have also strengthened the bond between human and companion animals. They can live together without fear of zoonotic diseases. There is much development in the production of new veterinary vaccines, but there is a need to sit together for new emerging diseases. There should also be work on reducing vaccine costs for animals and providing vaccines to developing countries.

14.2. TYPES OF VACCINES

Safety concerns of the world led to the development of different types of live attenuated vaccines. Each new type is being developed to boost immunity with fewer side effects. Roughly 4 general categories of vaccines have been made.

14.2.1. Live Attenuated Vaccine

Live attenuated vaccine is usually made for viruses and contains organisms that have been weakened to the level that cannot cause disease. There are several methods to develop a live attenuated vaccine but the most common is the growth of the virus several times on the unnatural host cell line or tissue culture. There are several examples for the development of this type of vaccine, including oral Polio vaccine, Influenza, and Rotavirus vaccine [2].

14.2.2. Inactivated Vaccine

In this method, vaccines are produced through inactivation or killing of the organism through heat or chemicals so that immunogenicity remains intact. The antigenic epitope has to be intact during the inactivation process. Flu, rabies and hepatitis vaccines are produced with this method.

14.2.3. Recombinant/Subunit Vaccine

These vaccines only use some parts of the organism, which produces a strong immune response in the body. Bacteria or virus's structural parts of protein can be used. Protein antigens can also be produced in some other non-pathogenic organisms through genetic engineering of the genome nucleotides. Vaccines for Hepatitis B and whooping cough are examples of this type of vaccine. They may need booster doses for proper immunization.

14.2.4. Toxoid Vaccine

Most of the time, this type of vaccine is produced against the toxins of bacteria. Some of the bacterial toxins damage the body of animals or humans than bacteria itself. These toxins are modified or weakened and given to the host. This toxoid

CHAPTER 15

Role of Nanoparticles in Veterinary Medicine and as Feed Additive in Livestock

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Abstract: Nanotechnology is gaining more popularity in various applied fields due to its versatile applications. Different world challenges, including pollution, resistance against antibiotics, disorders in human/ animal digestive systems, contaminants of feeds, health management & feed efficiency, *etc*., can be overcome by using nanoparticles. Nanoparticles can be used as antibiotics, as feed additives, and can also be used against mycotoxin and as biocidal agents. The efficiency and productivity of various items could be improved using multiple supplements like enzymes, yeast, plant extracts, *etc*. Many efforts are going on to improve productivity and efficiency using different supplements, such as yeast, enzymes, probiotics, and plant extracts. Nanomaterials can effectively replace all. In this chapter, we will discuss various types of metal/metal oxide nanoparticles and their role in livestock as feed additives, pointing out their level of toxicity as well. The current and future regarding the permissible nanomaterials to be used in veterinary-related products will also be highlighted.

Keywords: Livestock, Nanoparticles, Nanotechnology, Nanomaterials.

15.1. INTRODUCTION

Human history is full of changes and transformations, and at present, we are encountering day-by-day development. Thanks to the scientists and engineers working very hard in different fields to explore and develop technology that can benefit the coming generations. Among all the developments, nanotechnology is one. In nanotechnology, the organic and inorganic matter is minimized to the sizes between 1 to 100 nm and hence can be easily incorporated into medicines, antimicrobial activities, drug delivery, electronics, cosmetics, and food packings.

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At the nanoscale, the particle properties are enhanced, and for that reason, nanoparticles have frequently been used in animal production and health [1].

Nanoparticles can act as an alternate solution to many challenges the world faces nowadays. These challenges include pollution, resistance against antibiotics, disorders in human/ animal digestive systems, toxic contaminants of feeds, health management and feed efficiency, among others. Nanoparticles can be used as antibiotics and as feed additives. They can be used against mycotoxin and as biocidal agents [2]. Many efforts are going on to improve the productivity and efficiency by using different supplements such as yeast, enzymes, probiotics and extracts from plants. Here, nanoparticles can be utilized as a new feed additive and in health treatments for updated animal nutrition [3].

There are many promising results from livestock where organic nanoparticles have been used effectively to enhance the nutrient value [4]. Apart from increasing the nutrient values, these nanoparticles can help reduce feed costs because it has been reported that less quantities, compared to normally used mineral resources, can have significant effects [5, 6]. Furthermore, these nanoparticles have certain special features, such as small sizes, higher surface area and surface charge, and strong absorbing ability, which make them suitable for the above-mentioned applications. Therefore, nanoparticles used as a feed additive or medicine can be named nano-nutrition.

15.2. NANOPARTICLES AND LIVESTOCK

Organic nanoparticles are usually considered nontoxic and biodegradable and, therefore, can be considered a good drug delivery agent. While using these nanoparticles, their sizes, structure and morphology are very important. At the same time, their drug-carrying power and stability are also very crucial. These features will decide the particular nanoparticle's performance while being used in drug delivery. Organic nanoparticles can inject on a specific site, carrying either trapped or absorbed drugs. Ferritin, dendrimers, micelles, liposomes, *etc*., are recognized as organic nanoparticles [7]. Silver, gold, iron, lead, aluminium, copper, and zinc are among many metals that can be transferred from metals to nanometric scales by employing different nanoparticle synthesis techniques [8]. Metal-based nanoparticles are oxidized to change their features, making them more reactive and efficient [9]. Carbon-based nanoparticles are formed of carbon entirely. They include graphene, fullerenes, and carbon nanotube [10].

Nanoparticles can be used for a variety of veterinary applications. They are used to destroy cancer cells, drug delivery systems and antimicrobial agents [11, 12]. These nanoparticles can also have toxic effects as they are reported to accumulate in the liver, and lung tissue of sheep, rats, and fishes. Also, there are reports of their accumulation in the brain of laboratory animals [12]. Therefore, parallel to the benefits of using nanoparticles in livestock, it is also very important to study the toxicity of the nanoparticles.

15.3. NANOPARTICLES AS FEED ADDITIVES

As a feed additive, the nanoparticle can be used to administer medication, nutrients, probiotics, supplements and other substances. Some minerals in the form of nanoparticles can be prepared and delivered to livestock to fulfill their mineral requirements. The advantage of these nano additives is that they have better bioavailability, small dose rates can be used, and they are reported to have stable interaction with other components. Due to their low dose usage, these nano additives can be used as an antibiotic alternative. They can act as growth promoters, eliminate antibiotic residues in animal products, reduce environmental contamination and helps in the production of pollution-free animal products [13]. These nano additives can also be encapsulated together with protein or other natural feed ingredients. Nano-capsules made with nanoparticles have improved bioavailability and hence can act as carriers of essential oils, flavors, antioxidants, enzymes, vitamins, minerals and phytochemicals [14]. Analysis and remedy for the risk and hazards related to using nanoparticles as feed additives are very important. Concentration and exposure time are very important factors that need to be kept in mind before using these nanoparticles in feeds. Substances with high-risk factors but exposure for little can be less dangerous than those with limited risk but exposed for longer times. Therefore, it is of great concern that the nature and exposure time should be defined.

The use of nano additives in the nutrition of animals requires proper risk analysis, and there should be regulatory policies. Timely assessment of the potential, technical, and societal factors of these nanoparticles is of utmost importance, and for this purpose, globally, there are many regulatory frameworks and various approaches that ensure the safe use of nano products in agriculture, feed or food [15].

15.4. INCREASED MILK AND MEAT PRODUCTION

Progressive responses have been attained with the nanoparticles when fed as a substitute to the traditional sources of minerals. Using nano zinc as a feed additive to livestock has generated positive results in reproduction, growth, and immunity. For example, a decrease in somatic cell count in subclinical mastitis cows and a rise in milk production were detected with nano zinc oxide supplementation [16,

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