Importance of Heifer Development for Dairy Farming

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1. Introduction to Heifer Development

Heifer development for Dairy Sector means that growth phases of selected female calves are planned and managed such that maximum milk production is achieved, beginning from the first lactation cycle, ensuring minimal variations and least negative impact on the animals' health and productive status. The success of dairy farmers depends upon how they manage heifers to maximize heifer competence through body condition score, live body weight, ideal hip height, feed efficiency and average daily gains at key target points based on standard height and weight of an adult cow. Heifer development have been a major focus for dairy farmers as it is generally presumed that intense management systems for heifers are least cost effective and require extensive management inputs. Dairy farms employing intensive on-farm operations management practices record positive farm productivity by reduction in disease incidence and subsequent treatment, mortality losses and labor costs along with improved average daily gains.

2. Importance of Heifer Development for Dairy Farming

Heifers form the foundation of a dairy farming enterprise. Dairy farmers can improve their dairy herd by replacing culled cows with well-fed, healthy, genetically superior two-year-old heifers. Mostly, dairy farmers replace 25-30 % of the herd every year. These replacements have a significant financial impact on the farm.

On a dairy farm, every born female calf is not given a chance for breeding and lactation. The earlier the culling decisions are made, more profitable is the heifer rearing program. Farmers need to monitor important performance indicators such as age at first breeding, age at first calving, milk production in first lactation and calving interval etc. Similarly, it is important to monitor and record early life indicators such as birth weights, average daily gains till 150 days of age, disease resistance etc. Based upon efficient and timely monitoring, effective culling decisions can be made prior to further investment for complete rearing of a heifer to a mature cow.

Traditionally, dairy farmers focus on developing the heifers on their own farm through selection of superior female calves from their own cow herd. However, other markets in the form of milk producers and livestock growers also exist for the purchase of 'bred' replacement heifers. Dairy farmers raise healthy, well- grown heifers that calve and enter the milking herd at 22 to 24 months of age. Special attention is given to heifers' reproductive management so that the herd attains average calving age of 23 months. The purpose of this practice is to provide replacements for retired cows leaving the herd and to improve genetic progress. The practice of rearing replacement herds on farm by the dairy farmer is a high investment option for high future economic benefits.

3. Pakistan's Dairy Sector

Livestock is an important part of the food chain as they transform roughage such as grass, shrubs and green leaves into quality-food; milk and meat which are source of superior protein and essential amino acids. It is an important sub-sector of Agriculture and accounts for 60.5% of agricultural GDP and 11.2% of the total GDP.

Cattle crossbreeding started in Pakistan in 1970s. It was clearly found after experiments at public sector farms that crossbred cattle showed better pergformance as compared to their dams in terms of production parameters such as milk production. Thus, crossbreeding has been carried out through government A.I. network. In addition, male exotic animals were also provided to the interested farmers to be kept at farms for natural breeding. Exotic semen used in crossbreeding included Holstein Friesian, Jersey and Swedish Red and White, etc. Initially, crossbreeding experiments were carried out on local breeds using Sahiwal and Cholistani cattle.

However, later a national breeding policy was formulated, which encourages selective breeding in Sahiwal and Red Sindhi cattle and crossbreeding was limited to only non-descript cattle with limited or no genetic worth and pedigree. Currently, there are about 4 million crossbred cattle in Pakistan.

3.1. Important Livestock Breeds in Pakistan

Pakistan has a large livestock population which is not only well adapted to local conditions but also has some of the best tropical dairy breeds. Current estimated livestock population (2019-20) includes:

Table 1: Livestock Population (Million Heads)[1]

Species	2016-17	2017-18	2018-19	2019-20
Cow	44.4	46.1	47.8	49.6
Buffalo	37.7	38.8	40.0	41.2
Sheep	30.1	30.5	30.9	31.2
Goat	72.2	74.1	76.1	78.2
Camel	1.1	1.1	1.1	1.1

[1] *Note: Estimated figures based on inter census growth rate of Livestock Census 1996 & 2006, Economic Survey of Pakistan, 2019-20*

Table 2: Milk Production & Consumption[2] (Million Tons)[3]

Species	2016-17	2017-18	2018-19	2019-20
Cow	20.14	20.90	21.70	22.51
Buffalo	34.12	35.14	36.18	37.26
Others (sheep, goats, camel)	1.82	1.85	1.88	1.93
Gross Milk Production	56.08	57.89	59.76	61.70
1. Milk for Human Consumption (80%)	45.23	46.68	48.18	49.36
2. Wastage during transportation (15%)	8.41	8.68	8.96	9.24
3. Milk for calves (5%)	2.80	2.89	2.99	3.10

There are ten distinct breeds of cattle found in Pakistan. Their production characteristics are as follows:

Table 3: Typical Characterisrics of Cattle Breeds of Pakistan

Breed	Type	Areas of Concentration	Adult Body Weight (Kg)		Age at Maturity (days)	Milk Yield/ 305 days	Lactation length (Days)
			Male	Female			
Red Sindhi	Milch	Western Sindh, Lasbela, Balochistan	530	325	852	1675	270
Sahiwal	Milch	Sahiwal, Okara, Multan, Faisalabad	544	408	861	1852	283
Bhagnari (Kachhi)	Draught	Bhag Territory, Kalat, Northern Sindh	650	480	966	950	262
Dhanni	Draught	Attock, Rawalpindi, Chakwal, Jhelum	412	285	910	800	204
Lohani	Draught	Loralai, D.I. Khan	315	253	900	613	163
Rojhan	Draught	Suleman Range, D.G. Khan, D.I. Khan, Kohat, Bannu	370	267	-	735	192
Tharparkar	Dual	Tharparkar areas	470	285	891	1584	277
Cholistani	Milch	Cholistan area	470	341	609	1471	285
Kankreg	Dual	South West Tharparkar	591	432	-	1200	-
Dajjal	Draught	Dajal area, D.G. Khan	587	400	-	900	257

[2] The figures for milk production for the indicated years are calculated by applying milk production parameters to the projected population of respective years based on the inter census growth rate of Livestock Census 1996 & 2006. Milk for human consumption is derived by subtracting 20% (15% wastage in transportation and 5% in calving) of the gross milk production of cows and buffalo.

[3] Estimated figures based on inter census growth rate of Livestock Census 1996 & 2006. Economic Survey of Pakistan, 2019-20

It is to be noted that the breeds mentioned in the afore compiled table represent approximately 30% of the population only; the remaining population is generally classified as non-descript. Crossbreeding of local cattle with exotic semen (particularly Holstein-Friesian and Jersey) for improved milk-production has become a popular practice in the Dairy Sector of Pakistan.

3.2. Import of Breeding Cattle in Pakistan

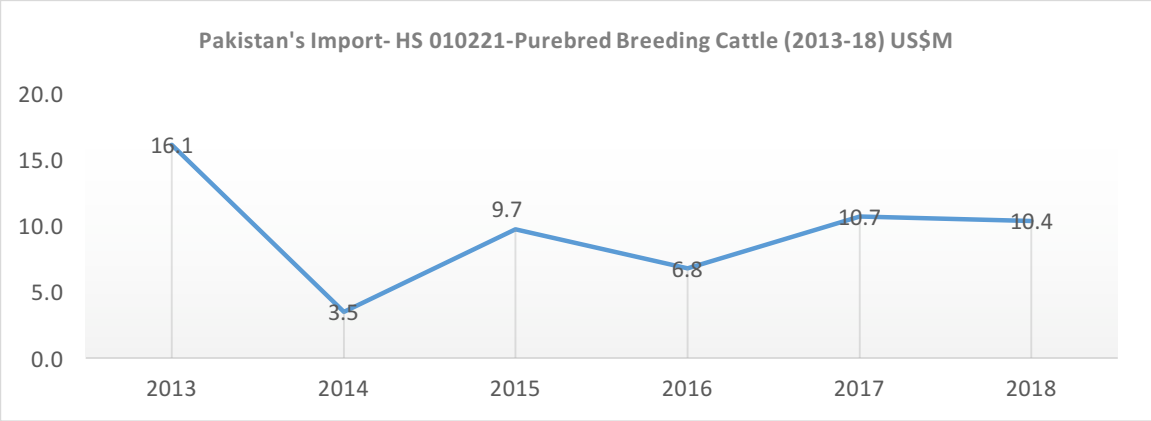
During the last ten years, Pakistan has seen a shift towards commercial and corporate farming and several hundred new dairy farms have started operations during this period. Majority of these farms have used Holstein cows imported from Australia. Pakistan imports live cattle every year as reflected under the Trade Map HS Code: 0102, Live bovine animals[4];

Table 4: Pakistan Imports : HS 0102 (Live Bovine Animals) US$M

Product Label	HS Code	2013	2014	2015	2016	2017	2018
Pure-bred cattle for breeding	0102-21	16.13	3.52	9.71	6.80	10.70	10.35
Live cattle (excluding pure-bred for breeding)	0102-29	4.62	0.55	0.06	0.00	0.00	0.75
Live bovine animals (excl. cattle and buffalo)	0102-90	0.00	0.00	0.00	0.01	0.00	0.00
Pure-bred breeding bovines	0102-10	0.00	0.00	0.00	0.00	0.00	0.00
Total		**20.74**	**4.07**	**9.77**	**6.80**	**10.71**	**11.10**

Under category HS 0102-21 of live breeding cattle, Pakistan imported breeding cattle - heifers worth US$ 10.35 Million in year 2018.

Figure 1: Pakistan's Imports of Purebred breeding cattle (US$M)



[4] www.trademap.org

During years 2014-18, Pakistan has imported heifers from Australia, Netherlands, USA and UK; with a major share being from Australia. Pakistan imported heifers from Australia, Netherlands and USA worth US$ 10.5 Million with share of 69%, 25% and 6% respectively in year 2018.

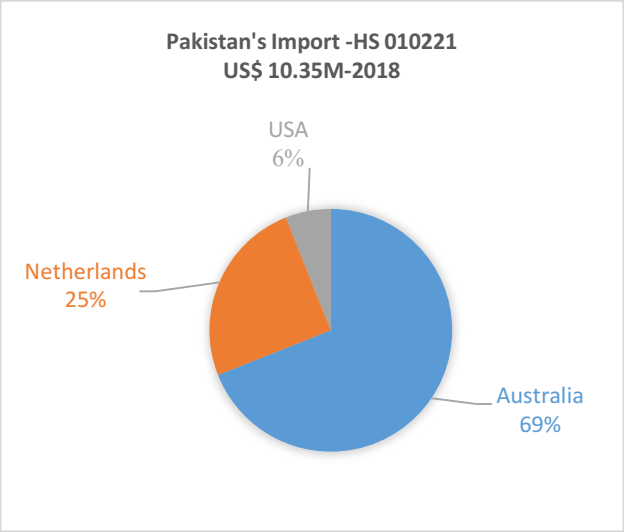


Figure 2: Pakistan's Imports of breeding cows

3.3. Genetic Improvement – Past and Present Initiatives of the Government of Pakistan

The Government of Pakistan has taken a number of key short term genetic-improvement programs in the Dairy and Livestock sector. Likewise, livestock-breeders have also historically been trying to improve breeds that fall within their interest. In absence of production records kept at farms, the breeders base selection of animals on physical characteristics of the breed; such as eye colour, coat colour, tail length and shape of horns, etc.

Government- sponsored genetic improvement programs implemented in the past include:

A. ***Supply of Bulls:*** Pedigreed or selected bulls from elite mothers were supplied by the Government to interested farmers in pre-identified geographical locations. These bulls or bull calves were either selected from the Government Livestock Farms or purchased from progressive farmers. Sometimes, these bulls were also kept in veterinary hospitals for free breeding services to interested farmers. Similarly, bulls were also maintained in some villages through Lumbardari schemes in which, the Lumbardar (village head) was granted some land for maintenance of breeding bulls for local cows and buffaloes. However, this initiative has been discontinued.

B. ***Land-Grant Schemes:*** In pre-partition India, the British Government granted large pieces of land on long lease as "Land Grants" to the farmers for conservation and propagation of livestock breeds. A significant example is the establishment of Bahadurnagar Farm, by leasing 3,049 acres of land in 1916 to a private farmer, to maintain 400 cattle of Hissar breed that was replaced with Nili and Ravi buffaloes in 1936. These schemes have also been discontinued.

C. ***Herd-Book Schemes:*** Government started a Herd Book Scheme for Sahiwal cow and Nili-Ravi buffaloes in their home tract, to encourage proper record keeping of animal production records. The scheme was operated under the supervision of the Government through the Livestock Department; whereby participating farmers were given land and veterinary aid as incentives. For example, Shergarh Herd- Book Scheme in Sahiwal district for Sahiwal breed. The iniative is possibly being pursued by select farmers currently.

D. ***Provision of Artificial Insemination (AI) Services:*** AI was started in Pakistan in the late 1950s. However, the implementation pace has been slow and to date, less than 10% of breedable cattle are covered through AI service. Currently, 189 AI Centres are operational. Semen of buffaloes (both Nili-Ravia and Kundi) and cattle (Sahiwal and Red Sindhi) is produced locally at four Semen-Production Centres. In addition to these, semen from Holstein-Friesian and Jersey cattle is both produced locally and imported from other countries.

   Historically, bull selection for AI has been a major problem. Bulls were initially purchased from farmers having better producing animals or from Government Livestock

Farms. However, in 1980 a progeny-testing program was launched for Nili-Ravi buffaloes, which was later expanded to include Sahiwal cattle. With occasional breaks, the program continues to be operational and at present candidate bulls for the two breeds; Nili-Ravi buffaloes and Sahiwal cattle, are picked from 10-15% elite females.

This cycle is being maintained at both Government Farms and with registered farmers. However, it is pertinent to note that there remains a limited number of these bulls and the rest are still selected on the basis of available limited pedigree records.

E. ***Progeny Testing Program:*** A progeny testing program for Nili-Ravi buffalo-bulls was started in 1978. The work was, later on, expanded to include Sahiwal cattle also. Three buffalo- farms and selected village buffalo-population, at 27 sub-centres in three districts of Okara, Faisalabad and Sahiwal, were included in this progeny testing program. However, progeny- testing program of Sahiwal cattle has only been limited to public sector farms and surrounding villages. So far, 13 batches having 276 bulls of Nili-Ravi buffalo have been included in the program. Similarly, 12 batches having 94 bulls of Sahiwal cattle have also been handled.

   Through the program, 51 buffaloes and 21 Sahiwal bulls with positive predictive values have been identified. Semen of these bulls is available in A.I. Centers, as well as stored in Semen Production Units (SPUs).

F. ***Import of Exotic Genetics:*** Like many other countries, Pakistan has also imported exotic cattle in an effort to establish high yielding breeds in the local environment. Several exotic breeds of cattle, notably Holstein-Friesian, Jersey, Red Dane and Australian Illawara Shorthorn have been imported for establishment of nucleus herds, use in crossbreeding programs or as demonstration and commercial units of modern dairy-farming. These imports have been done in both public and private sector. In addition to poor adaptability, these animals under local environment and managemental conditions, usually lose their high production. A limited number of small Friesian and Jersey cattle herds are still being maintained by the public sector. Males are usually sold to interested farmers for crossbreeding of local non-descript cattle.

G. ***Cross*- breeding:** Crossbreeding in Pakistan has been carried out in cattle. Among the ten breeds of cattle, only two (Sahiwal and Red Sindhi) can be classified as dairy breeds; all others are low milk-producers. Furthermore, pure-bred cattle in Pakistan comprises 25-30% of the population and the rest are non-descript low producers.

Initiatives taken by the Government in recent times for the import of livestock and related products are primarily administered through Ministry of National Food Security & Research, Livestock Wing. These notable initiatives include;

- Allowing import of high yielding dairy cattle breeds of Holstein Friesian and jersey and their genetic material (semen and embryos) for genetic improvement of indigenous low producing dairy animals.
- Allowing import of high quality feed stuff/micro ingredients for improving nutritional quality of animal & poultry feed.
- Allowing import of dairy, meat and poultry processing machinery/equipment at concessional tariffs/dutys in order to encourage value addition in the Dairy Sector.
- Allowing import of 0.825 million doses of superior quality semen and 8,811 high yielding exotic dairy cattle such as Holstein-Friesian & Jersey breeds during 2018-19 (July-March); with the obejctive of genetic improvement of indigenous dairy animals.
- Facilitating the import of calf milk replacer & cattle feed in order to promote the corporate dairy sector and import of feed premixes at concessional tariffs. During 2018-19 (July-March), 364.6 Metric Tons of calf milk replacer and 297.4 Metric Tons of cattle feed premix has been imported.
- Protection of small dairy farmers and the corporate dairy sector; beside regulating import and mitigating use of synthetic milk and recipe products/tea whiteners, 25% regulatory duty has been imposed on import of Skimmed Milk Powder (SMP) and Whey Powder (WP). Currently, 45% in duty tarrifs are implemented on on import of powdered milk; import duty 20%, regulatory duty 25%.

3.4. Introduction

Pakistan's human population has reached approximately 220 Million heads which has outpaced a proportionate population growth of livestock. Further, total milk production from livestock herd has also been insufficient, creating a demand and supply gap. Demand of milk has been met by importing skimmed milk / powder milk which acts as strong indicator of milk shortage in the country.

With increasing urbanisation, younger generations of dairy and livestock farmers have migrated to metropolitan cities leading to a decrease in number of dairy farms and a reduction in population of high producing livestock. The same may result in a sharper reduction of highly productive pedigreed animals in the next 5-10 years. Other important include high input costs and lower yield of genetically inferior animals making them commercially non-feasible.

Considering the increasing demand of milk, high yielding genetically superior cattle is a need of the hour. On the other hand, the process of growing and developing genetically superior local breeds needs decades. The policies implemented are short-term. Genetic returns demand long-

term plannings and need persistent government focus to achieve the desired results. There is also lack of trained human resource and professionals in scientific dairy farming for long term genetic improvement.

Out of the total fresh milk produced in Pakistan, apprximately 5% is channallized to UHT and pasteurization processing. The remaining 95% is loose milk marketed without any traceability and produced by subsistence and small scaled dairy farmers. The number of these farmers may reduce in coming years due to urbanization and costly raw material and inputs. At the same time, demand for processed milk may increase although, majority of aware consumers are not comfortable with UHT milk suppliers, mixing skimmed milk or imported dry milk and selling it as milk. This is an anomaly especially at a time when the consumers are aware that globally pasteurized fresh and chilled milk is preffered.

Latest legislations are heading in the direction where all the milk produced is to be converted into pasteurised milk, and to ultimately ban loose milk. This will be an interesting situation as according to industry experts, nearly all dairy processing companies are currently running at around half of their installed capacity. Powderd milk is meeting approximately half of the demand of the processing industry. It is estimated that 40,000 to 50,000 tons of powder milk is being imported, whereas smuggling from neighbouring borders is also a big challenge for the sector. In order to grow the local industry, imports of powdered milk is discouraged by the Government through tariffs implemented on import of the same. This will increase the demand for local dairy milk by UHT processors, thereby increasing the demand for good quality breeds and bovine genetics. Even if imported powder is reduced by half, dairy farming in Pakistan could be doubled as per experts.

There is also a major problem of quality animal procurememt sources as there are no local suppliers of cattle of any local breeding animals. There is limited application of skills on farm breeding and selection practices in local market. Even the corporate or formal sector is not implementing proper breeding programs to maintain the genetic pool of animals, whether local or imported.

The corporate dairy farms are primarily large scale ventures that focus on commercial dairy animals, hence are not concerned with breed improvement planning. They follow international index of bovine semen, which are relevant for source countries but do not apply on main bulk of livestock population in Pakistan. Even imported exotic cows, mainly from Australia are cross-bred and need a well drafted breeding strategy to maintain and develop the breed.

There is a significant number of descript cross-bred local and exotic cows which helps to increase the gross milk yield. For the last ten years, low producing local breeds supplying almost 95% of nontraceable milk, are cross bred with imported high quality semen so that at least next F1 generation would show improved yields in comparison to their dams. If a local non-descript

cow yields 8 litres of milk daily and is crossed with imported semen of high genetic worth of production for 30 litres, then by cross breeding, the offspring is predicted to yield approximately 12-15 litres per day, depending upon factors such as the environment in which it is kept, feeding and nutrition and cow comfort farm practises.

Usually, farmers get their animals inseminated by imported semen as they are eager to get the increased milk production from the next generation without developing their own parameters of selection and culling for replacement heifers.

Pakistan has imported Holstein heifers for environmentally controlled commercial dairy farms in different regions of Punjab province. These heifers were imported from USA to Sialkot before being transported to dairy farms in Gujranwala, Sialkot and Kasur districts. Australia is the largest exporter where as USA is the second largest exporting country of dairy heifers to Pakistan by exporting upto 90,000 cows over the last few years.

Figure 3: A Typical Brown Swiss Heifer

These heifers cost anywhere from US$ 2,000 – US$ 4,000 in Pakistan depending on their genetic worth. This cost is almost twice than that of local cows of the same age. Key difference between local and exotic cows is milk yield of the animals. Average daily milk yield of a local cow is 12-15 litres against 35 to 40 litres of an imported purebred cow of superior genetics. This is the main reason that the demand for cows of exotic breeds has been on the rise in Pakistan, the country otherwise ranked fourth largest milk producing nation in the world only after India, China and USA. The import of cows from Australia and USA and their cross breeding with local varieties can be of great use in bringing Pakistan's dairy sector at par with other agriculture economies of the world.

Figure 4: Young Heifers in a Controled Dairy Shed

3.5. Way Forward

To develop local dairy breeds of Pakistan, there is need to improve their genetic quality with a focus on developing and retaining pedigreed animals with known genetic worth and increased milk yields per animal. Dairy farmers must be sensitized towards the fact that a pedigreed cow comes with certified records of at least three generations relating to feed, production patterns, farm history, breeding dates, semen history, type of semen, etc.

In short term, greater focus is required for better farm practises and import of quality breeds or at least their genetics. Cows from local breeds such as Sahiwal, if not pedigreed and genetically proven, may not produce optimum due to low productivity values and genetic potential from a commercial point of view.

There is also need to preserve and propagate indigenous cow breeds too, as they are national assets and heritage breeds. In addition, they have strong resistance to diseases, harsh weather and environmental conditions. This may be done through production of sexed semen of local breeds to produce more female calves and then genomic selection of these female calves as replacement heifers. This will encourage the farmers to keep only high producing animals

Dairy heifer replacement raises significant interest among dairy sector stakeholders. Presently, due to absence of customised breeding plans, corporate farms established in various parts of the country have been importing heifers and cows from countries such as Australia, Holland and USA in the past 5 to 8 years. The heifers and cows which have completed their successful productive life of 4 to 5 years at most dairy farms would be shortly culled from farm. However, to maintain commercial activity and profitability, the older stock must be replaced with the young heifers of same or even improved genetic potential for milk.

Import of dairy animals requires high input costs and extensive paper work which imposes a pressure on sustainability of farm economics especially when farmer is starting a new dairy enterprise. Furthermore, international politics and world economics may contribute to delayed supplies. It is, therefore, important that the replacement stock be raised locally. Production of high genetic potential heifers at low costs is challenging and requires large resources to be spared for research and propagation of research outcomes.

The following factors are key considerations when deciding to opt between on-farm replacement heifers, contract raise and purchase.

On-farm Replacement Heifers: A key advantage of raising heifers on the farm is maximum control of heifers starting from day of calving which reduces biosecurity risks which otherwise could not have been controlled e.g. ensuring consumption of colostrum by new born calf for the development of natural defence mechanism system to combat diseases. Further, management and genetic makeup of the animals is known to the farmer. Disadvantages of on-farm heifers include additional labor costs and provision of additional facilities.

Contract Raising:. The advantage of contracting heifers for rearing from a custom heifer grower is that it frees facilities and reduces labor costs for the dairy farmer. The genetics of heifers are known by virtue of adequate documentation and biosecurity risks are generally low as compared to purchasing heifers. Contract raising used by dairy farmers allows for ease in cash flows as the heifer grower is paid service charges near the time of calving. Drawbacks of contract raising include loss of management control and quality assurance, which can be

mitigated through predefined guidelines outlined in the contract between the dairy farmer and heifer grower.

Purchasing Heifers: A primary advantage of purchasing heifers is that it frees financial investments which needed for additional infrastructural facilities and labor costs, allowing the dairy farmer to concentrate on the development of genetically superior adult milking herd with high production parameters such as milk production, decreased calving interval, improved reproductive performace etc.. However, disadvantages of purchasing heifers include availability of quality replacement heifers, biosecurity risk associated with bringing animals into the herd, time required to acquire heifers and risk of paying higher prices for the heifers. It is to be kept in consideration that usually high quality heifers are in limited supply.

4. Focusing on Heifer Development

Female calf raising is considered amongst the highest costs on farm, yet the farmer should consider raising their own replacement heifers due to its advantages. It is important to understand that the quality of today's calf-raising program will determine the production and income of dairy farm in upcoming future years.

4.1. Selection of Sire and Dam

Calf raising actually begins with the breeding process itself. Genetic inheritance of the calf is established when the cow or dam is bred. The sire and dam each contribute 50 % to genetic inheritance of the calf. Since the dam is already raised on farm, little is needed to change the dam's contribution for calf's genetic makeup. The greatest effect on inheritance will come from judicial selection of the sire. Selection of genetics from bull's side having superior genetic worth offers the greatest opportunity for improvement in a herd.

4.2. Care of a Pregnant Dam

Pregnant cows should be treated gently and with special consideration after the identification and confirmation of pregnancy within 90 days of Artificial Insemination (AI). First quarter of the gestation period is critical as in the early stages of pregnancy, any disturbances can cause abortion. It is recommended to ensure a minimum 45 – 60 days of dry period before expected day of calving. Long distances and slippery surfaces should be avoided. Cows should be kept in confinement so as to avoid any contact with other animals especially dogs and bulls or infighting between pregnant animals. The pregnant cows should also be quarantined from other sick cows who have had a recent abortion or act as a carrier of diseases like Brucellosis. Provision of adequate clean drinking water ad libitum is necessary.

4.3. Calf Care at Calving

The cow (dam) should be transferred to a clean and dry calving pen atleast 10 days prior to the expected date of calving. She should be observed often but left alone unless veterinary assistance is necessary. If she needs assistance at calving, properly sterilized equipment should be available including a bucket, obstetrical pulling chains, soap, ample lubricant and disinfectant solutions. The arms and hands of the person assisting should be clean and sanitized. Correcting any abnormal position of the calf and using generous lubrication are two vital procedures for assisting in calf delivery.

Some important points to be strictly observed after birth of the calf are;

- Dip the navel cord in a strong iodine solution the following day. This practice kills existing organisms on the cord and decreases the risk of complications from "navel ill".
- Identify the calf by ear tag or neck strap.

- Apply tattoo on both ears especially Brucellosis vaccination tattoo in the right ear.
- Dehorn the calf within first 10 days.
- Weigh the calf and record the weight in a calf book. A heart girth tape is to be used in determining their weight. Record tape measurements in inches if a special weight tape is not available.
- Make a record card for the calf (tattoo, sire, dam, birth date, and birth weight.) Other information such as colostrum quality, etc., can also be recorded.

4.4. Housing Management of Calves

Design, construction and maintenance of housing facilities for calves is considererd to be very important to optimise the animals' performance and well being. Welfare and well being of calves is ensured by reducing:

- hunger and thirst through ready access of fresh water and a nutritionally balanced diet to maintain health
- physical discomfort through provision of appropriate shelter and comfortable resting areas
- pain through preventive measures; rapid diagnosis and treatment when needed
- abnormal behaviourial patterns through provision of adequate space, proper facilities and company of other animals

Key factors to consider when planning for a calf/ heifer rearing facility is described in the following diagram:

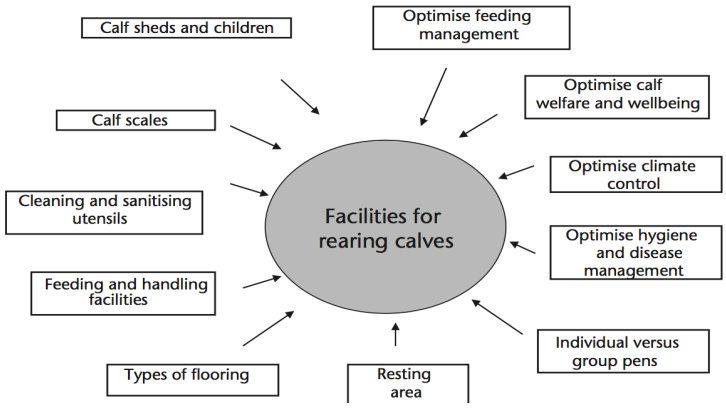


Figure 5: Important Factors of Heifer Rearing Program at a Typical Dairy Farm

Infrastructural facilities and equipment should be well designed, maintained and operated to ensure high level of animal welfare, minimal stress and chance of injury. The following must be ensured:

- Protection from extreme weather
- Provision of sufficient space with minimal possibility of injury
- Flooring designed to minimise slipping, falling and lameness
- Facilities for water, feeding and restraint properly designed and maintained
- Laneways, tracks and gateways designed to minimise stress and injuries
- Equipment for euthanasia in good working order

Figure 6: A typical Tagged and well placed calf

The calves are placed in individual, clean, dry and well-bedded pens placed in a clean area at farm premises. They should be kept in their pens by the order of chronological age, where they are unable to touch each other or be disturbed by older animals.

Several types of calf facilities are recommended, including individual calf hutches or pens with three solid or slatted walls. The 'Outside portable pens' are most successful. Calf barns should be well-ventilated and kept free of winds and drafts.

Figure 7: A sketch of housing facility for calves

When the calves are 4 months old, they should be moved to a bigger shed facility. The feeding area for each calf from 4 -11 months of age should be 6 inches; calves of 12 to 17 months of age need 12 inches and heifers over 18 months need 18 inches of feeding area to ensure adequate feed availability.

As the dairy heifers grow, their housing requirements change. They should be kept in dry, well-ventilated, draft-free sheds that have sufficient bedding with 65% - 67% relative humidity, 25^0C - 28^0C temperature and free of any unpleasant odor. In addition, farmer must have a handling facility for routine health examinations and breeding.

Figure 8: Holstein Friesien at Dairy Farm in Punjab, Pakistan

4.5. Nutrition and Feeding Management

Nutrition and feeding management of calves forms an important basis for a well functioning heifer development initiative. In this section, standard nutrition and feeding practices are highlighted.

For the first three days after calving, a calf is given two equal feedings of colostrum and milk daily. After that, pasteurized whole milk, fresh or fermented colostrum or milk replacer may be fed twice a day at the rate of 12% of initial body weight from birth to weaning.

Figure 9: Feeding of new born calf

Within a few days of birth, the calf consumes fresh water and small amounts of grain. Once weaning occurs at 4 to 6 weeks of age, the calf should consume at least 1.5 – 2.0 pounds of grain daily. Following weaning, once the calf starts consuming 5 to 6 pounds of grain daily, it can have hay or other forage on a free-choice basis. Regardless of the type of forage feed, all ages of heifers should receive a grain mixture. The amount fed depends partly on the calf's age, but primarily on the quality of forage.

After the calves are 9 months old, they can be put on pasture, supplemented with small amounts of grain and forages. Feed additives such as ionophores (monesin and lasalocid) can be used to help improve the heifers' dietary energy effciency. Feeding ionophores will enhance heifer growth and increase their feed utilization. Fresh water must be continually available at all stages of the dairy heifer's life.

Food and water should be provided with consideration to environment, age and body condition as it ensures calf health, wellbeing and improved productivity. The calves should have access to appropriate quantity and quality of food and water. They should be fed formulated and balanced rations to provide necessary nutrients for their desired level of performance. Short- and long-term plans should be in place to manage food and water shortages and drought. Practices should be in place to reduce the potential risk of toxicity or contamination during feed storage. Always follow strict sanitation practices. Thoroughly clean and sanitize buckets and nipple bottles after each use. Arrange calves in chronological order by birth dates.

Extra caution should be exercised for sick calves by feeding them at the end, after all healthy animals to avoid spread of disease. Clean and fresh water should be provided ad libitum. The incidence of scours is lower when calves are given free-choice of clean drinking water.

4.5.1. Importance of Colostrum Feeding

The importance of colostrum feeding cannot be ignored as a calf is born without any immunity (resistance) to infection and disease. Colostrum feeding is mandatory within 15-30 minutes at the rate of 10% of live body weight of calf for three continuous days. After that, composition transforms into regular milk. Newborn calves acquire both immunity against many diseases as well as certain minerals and vitamins from the cow's first milk, colostrum. Antibodies (immunoglobulins) in the colostrum are absorbed through the intestinal wall during the first 24 hours of life, with absorption beginning to decline about 2 hours after birth. Hence, the calf should be given its first colostrum after calving as early as possible.

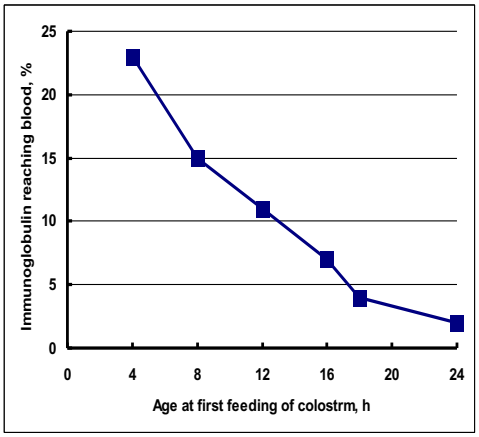


Figure 10: Absorption of Immunoglobulins Vs age of calf (hrs)

Some suggestions for effective colostrum are;

- Calves should not be directly nursed by dam. Feeding with a bottle would be helpful in measuring the amount of colostrum fed and hence allows to check for antibody content. This can be done by using a relatively low-cost colostrometer. Good-quality colostrum will have a reading of at least 75 to 100 mg/dl.

Figure 11: Quality check for colostrum

- Calves should be given colostrum immediately after birth. Tube feeding is recommended for calves which are unable to suck a bottle. Each calf should be given 1.5 to 2 gallons in the first 24 hours of its life. A suggested schedule is 2 quarts within 4 hours of birth, 2 more quarts within 12 hours of birth, and 2 more by 24 hours of birth.

- Since most cows produce more colostrum than their calves need, freeze the rest to save for the occasional calves that need higher quality colostrum than their dams can produce. Freeze colostrum that has a concentration of 75 to 100 mg/dl or higher. Two-quart containers are convenient, and they should be labeled with the date and concentration of collection.

- Maintaining colostrum quality should be a huge priority on the dairy as the quantity of colostrum would not matter if its junk.
- Colostrum can be stored in the fridge for one week only below 4^{O} C. However, it may be frozen in refrigerator at 0^{O} C for around 6 months to reduce onset of bacterial growth.
- Colostrum is best thawed with warm (not hot) water. Colostrum can be thawed in a microwave for short period on very low power.

Figure 12: Storage of Colostrum

4.5.2. Liquid Feeding

Extra colostrum and milk from antibiotic-treated cows can be used to feed calves. The amount of liquid (milk or replacer) to be fed daily should be 8% to 10% of live body weight. Many calves perform well when fed all their milk allowance at one feeding time in a day. Once-per-day feeding saves time in feeding and washing nursing buckets.

Table 5: Suggested Schedule of Milk Feeding for Calf

Schedule of Milk Feeding							
Body Weight (Lbs)	Age (weeks)						
	1	**2**	**3**	**4**	**5**	**6**	
60	5.5	6	7	6	4	**Weaning**	2 lbs/ day starter ration
70	6	7	8	7	4		2 lbs/ day starter ration
80	7	8	9	8	5		2.5 lbs/ day starter ration
90	8	9	10	9	5		2.5 lbs/ day starter ration

It is considered acceptable to use good quality milk replacers. The label on milk replacer bags will display information needed to assess ingredients and nutritional value. Generally, milk replacers high in milk by-products and low in plant by-products are considered of higher quality. Replacers should be at least 20% protein, not less than 12% fat, and less than 1% fiber. Mixing should be done according to the manufacturer's recommendations. Calf performance information collected on farm will assist the farmer in evaluating the milk replacer used.

4.5.3. Dry Feeding

The calf is offered a special starter feed. Only a small amount of special starter feed is fed initially which is gradually increased as the calf's appetite increases. The feed is changed on a daily bais. A good calf starter (with approx. 20% crude protein) includes:

Table 6: Formulation of Typical Calf Starter Ration

Sr No.	**Feed Ingredient**	**Inclusin Rate (%)**
1	Coarsely ground corn	50
2	Crushed or rolled oats	15
3	Soybean meal - 48%	25
4	Dried molasses	6.5
5	Limestone	2
6	Dicalcium phosphate	1
7	Trace mineralized salt	0.5
	Total	***100***

Following supplements are also required to be added:

- Vitamin A 3,000 IU[5] per lb starter
- Vitamin D 500 IU per lb starter
- Vitamin E 15 IU per lb starter
- Antibiotic 20 milligrams of terramycin or aureomycin per lb starter

Calves can be weaned when consuming 2 to 2.5 pounds of starter daily. Small amounts of high-quality grass hay may also be offeed at the time when calf is consuming 2 pounds of starter on a daily basis.

4.5.4. Scours Treatment

The new borne calves may suffer from scour. As the first sign of scours appear, electrolyte therapy should be started. A commercially available powder mixed with water is as cost effective as good homemade products. If the calf is bright and alert, there is little benefit of withholding milk. These calves may be fed milk and electrolytes separately. In weak or depressed suckling calves, only electrolytes, equivalent to 10% of body weight, is given on the first day. On second day, milk at 5% of body weight in addition to electrolytes should be started. After that, a gradual increase in milk allowance should be done to attain normal feeding in next 2 to 3 days.

Antibiotics may be indicated with scours, but many forms of scours are caused by viruses or other types of microorganisms. A qualified veterinarian must be consulted for guidance on the use of antibiotics in scouring calves.

[5] *Vitamins are added in Internatonal Unit (IU) per pound of grower ration.*

4.5.5. Feeding of Calves after Weaning

The calf is allowed to consume up to 5 pounds per day of calf starter along with hay. Starter is usually fed for up to 3 months. After 3 months, calves are shifted gradually to good grower ration. Following is a good calf grower mixture (containing approx. 18% Crude Protein or CP);

Table 7: Typical Calf Grower Mixture

Sr. No.	Feed Ingrediets	Inclusion Rate (%)
1	Coarsely ground corn	54.5
2	Crushed or rolled oats	15
3	Soybean meal (48%)	20
4	Dried molasses	7
5	Limestone	2
6	Dicalcium phosphate	1
7	Trace mineralized salt	0.5
8	Vitamin A[6]	2,000 IU/lb feed
9	Vitamin D	400 IU/lb feed
10	Vitamin E	10 IU/lb feed

The grower mixture is fed to calves for upto 6 months of age; after which calves are switched to herd concentrate.

[6] *Vitamins are added in Internatonal Unit (IU) per pound of grower ration.*

4.5.6. Feeding Heifers in Groups

Calves should remain separated after two weeks of weaning. After this period, they may be grouped. Grouping calves generally prevents sucking. Before grouping, deworming should be done with a good dewormer and vaccination (PI3, IBR, blackleg, and malignant edema). The following additional practices are to be done before grouping:

- Removal of extra teats
- Record live body weight
- Presence of intact identification ear tag
- Record of all vaccinations and body weights

From grouping to 6 months of age, 5 pounds of calf grower and high quality hay should be fed daily and free of choice, which may be substituted by pasture depending upon availability. From 6 months to 12 months of age, 0-7 pounds of concentrate daily is fed with limited feeding of silage, green fodder, or hay. The concentrate and silage with hay is fed to heifers from 12 months of age till the end of second trimester or 2-3 months before freshening, All heifers should continue to grow and gain weight but should not get overly fat.

Observing calves at least twice daily is extremely important. Detecting sickness early and giving prompt treatment cannot be overemphasized. Heifers should be checked daily for eye, foot, and sucking problems and other abnormalities. Immediate attention to a problem is important. At no time should heifers be placed with mature cows until 30 to 60 days before calving.

5. Health Management

The first few months of a calf's life are critical for producing a healthy animal. Digestive and respiratory diseases that occur in young calves often result from overcrowding, poor ventilation, improper nutrition, inadequate sanitation, and cold, wet weather. Therefore, the best kind of health program is a preventive one and begins with good housing and feeding.

A good management practice for farmers is to dehorn calves (and remove extra teats if necessary) at a young age. This is less stressful on the heifers if done at an early age. In addition, vaccinate heifers at 4 to 8 months of age and before breeding.

Parasites are a major and potential health problem. A routine deworming program for young calves should start at weaning and continue until 8 months of age. Heifers should be dewormed 3 and 6 weeks after being put on grazing in pasture. Coccidiosis can cause diarrhea in calves beginning at 3 weeks of age. Incorporating a prevention product, such as Coccidiostat or Ionophore can help control Coccidiosis. Calves should alo be treated for external parasites such flies, ticks, mites and lice.

Keep accurate vaccination and health records to help reduce death loss and ensure healthy heifers. Ear tags, neck chains, or freeze brands are good identification methods that help maintain accurate records. Consult with an expert to plan an effective preventive health program.

5.1. Vaccination and Deworming Schedule for Calves

Following is a tentative schedule for regular vaccination of young heifers.

Table 8: Tentative Schedule of Vaccination for Heifers

Age (Months)/ Stage	Vaccination/ Medication
1 month/ Heifer Calf	• Deworm (after weaning) • vaccinate for IBR, PI3, and blackleg
5 months/ Young Heifer Calf	Brucellosis vaccination • 7-way clostridium • IBR • PI-3 • BVD - killed vaccine • BRSV • 5-way Lepto • Deworm • Height and weight measurements
6 months/ Young Heifer Calf	• Repeat all vaccinations that used killed vaccines. • DO NOT REPEAT BRUCELLOSIS VACCINATION.
8 months/ Younge Heifer	• Deworm
12-13 months/ Yearling Heifer in 45 days prebreeding schedule	• IBR - killed vaccine • PI-3 - killed vaccine • BVD - killed vaccine

	• BRSV - killed vaccine • 5-way Lepto • Deworm • Height and weight measurements
14-15 months/ Breeding of Heifer	• Height and weight measurements
15 months/ Pregnant Pregnancy	• Deworm • Height and weight measurements
18 months/ Pregnant Heifer	• Deworm • Height and weight measurements • IBR - killed vaccine • PI-3 - killed vaccine • BVD - killed vaccine • BRSV - killed vaccine • 5-way Lepto
24-25 months/ Heifer at calving	• Height and weight measurements

Note: Consultation with a veterinarian is recommended for schedules and precautions. Feed Ionophores for Coccidia control up to 20 months old.

5.2. External Parasites

External parasites (flies and lice) should be controlled on a regular basis (approx. repeated at 10-day intervals) using an approved dairy cattle insecticide. This practice is important for good performance and sound udders. The use of Vigilante Boluses for fly control in late March and again in early July is a good control measure in an external parasite control program.

The ***Vigilante*** **bolus** is an insecticide used with both dairy and beef cattle to reduce the number of flies in an area. It works by releasing an IGR (Insect Growth Regulator) that stops the development of insects before they become flies essentially preventing them from reproducing. The bolus, when used with an insecticidal ear tag, devastates the populations of horn, barn and face flies. It contains 9.7% Diflubenzuron in a 50 gm bolus for 150-day control of horn and face flies including Organophosphate and Pyrethroid resistant flies. It also aids in the control of house and stable flies on beef and dairy cattle. Each bolus contains 4.75 gm of the active ingredient and can be administered with the standard balling gun. A single bolus will provide up to 150 days of control against Horn Flies and Face Flies.

5.3. Growth Chart

Growth rates before puberty have been shown to be related to the future productive life of cows. Inadequate or excessive growth rates are not economical. Optimum growth rates are not the same as maximum growth rates. Extensive research has established optimal growth rates for most breeds of dairy cattle. The charts below illustrate optimal growth rates for dairy cattle breeds i.e. Holstein and Jersey.

Table 9: Range of Recommended Weights and Heights for Holstein and Jersey Heifer[7]:

Recommended Weight and Heights								
	Holstein Friesien				Jersey			
Age (Months)	Weight (Lbs)		Height (Inches)		Weight (Lbs)		Height (Inches)	
	Min.	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*	*Min.*	*Max.*
1	133	156	31.7	33.3	93	108	29	32
2	178	210	33.5	35.3	122	146	30	33
3	225	264	35.2	37.2	155	177	32	34
4	272	320	36.9	38.9	183	217	34	36
5	320	375	38.4	40.5	233	278	35	38
6	368	431	39.8	42.1	259	321	36	38.5
7	417	487	41.1	43.4	303	362	38	40
8	466	542	42.3	44.6	335	412	39	41
9	514	598	43.4	45.8	373	436	39.5	41.5
10	563	653	44.5	46.8	391	483	40	42
11	611	708	45.4	47.7	428	499	41	43
12	659	762	46.3	48.6	471	548	42	44
13	706	815	47.1	49.4	500	571	42.5	44.5
14	752	867	47.8	50.1	535	602	44	45
15	798	918	48.5	50.7	565	640	44.3	46
16	812	967	49.1	51.3	583	661	44.6	46.3
17	855	1015	49.7	51.8	609	696	45	46.6
18	926	1062	50.2	52.2	639	753	45.3	47
19	966	1107	50.6	52.7	651	769	45.6	47.3
20	1005	1149	51	53.1	698	813	46	47.6
21	1041	1190	51.4	53.4	719	827	46.5	48
22	1075	1228	51.7	53.8	758	860	47	49
23	1107	1264	52	54.1	760	878	47.5	49.3
24	1137	1297	52.2	54.4	790	893	48	49.6

[7] *Reference: Extension Services, Mississippi State University*

5.4. General Farm Management Practices

- Heifers should be inspected regularly to monitor their health and welfare and routinely managed to minimise stress, injuries and diseases.
- Other routine husbandry procedures such as disbudding and calving induction (if required), are carried out to minimise pain and unnecessary suffering.
- Reproductive practices should be carried out competently to ensure good reproductive efficiency. Any disease, injury, illness and stress should be identified and treated promptly with suitable expert advice.
- All staff responsible for managing and handling heifers should be competent in their tasks and aware of their responsibility for good animal care.
- Staff carrying out routine husbandry, surgical procedures, reproductive procedures, administering health treatments and handling and transport of cattle should be properly experienced and trained.
- All staff related to handling of stock should identify signs of illness, abnormal behaviour or stress signs and ensure to take immediate and appropriate action accordingly.
- There must be availability of atleast one competent person on site or in contact with the staff on duty so that emergencies can be handled.

6. Biosecurity Measures

Biosecurity is a set of management practices that reduce or prevent the introduction of any disease on a farm. Every person who is involved with the farm (production management, labor, service providers, breeder and veterinarian services) has a role in minimizing the introduction of disease into a herd.

Before animals are brought to the farm, ensure to check the history of herd's health to determine if calves are coming from a reliable and reputable source. Also, ensure implementation of a reasonable animal-testing program on all heifers that enter the herd.

It is very important to quarantine and observe new animals introduced to the farm for 2 to 4 weeks to minimize the spread of diseases which are of serious health concerns on a dairy farm. Some of these are bovine viral disease, salmonella, foot rot, Johne's disease.

Having a good health program is critical to the success of a dairy farm. Consultion with a veterinarian, extension specialist, or other agricultural professionals, to implement an effective herd health plan for operations, is highly recommended.

7. Reproductive Management

Heifers should be ready to breed at 13 to 15 months so they are able to calve around 24 months. The key to a successful breeding program is proper nutrition, a preventive health program, routine heat detection, and timely insemination. Keeping accurate heat date and breeding records is an important aspect of a heifer breeding program.

Reproduction is an important consideration in the economics of cattle production. In the absence of regular breeding and calving at the appropriate time, cattle rearing will not be profitable. A generally accepted goal of a dairy farmer is to have healthy calf every year. This is possible only by increasing the reproductive efficiency of animals.

Successful reproduction encompasses the ability to mate, the capacity to conceive and to nourish the embryo and deliver viable young ones at the end of a normal gestation period. In fact, interruption in this chain of events leads to failure of the cow to conceive ,the embryo to die or premature delivery of the foetus.

The reproductive efficiency is a complex phenomenon controlled by both genetic and non-genetic factors. The non- genetic factors being climate, nutrition, and level of management. The reproductive efficiency varies not only between species and breeds but also among the animals within the same breed. Even the best of feeding and management cannot coax performance beyond the genetic limit of an inferior animal. Improving the genetic merits of livestock populations is important at all levels of management. A sound breeding program is a necessary part of the animal production system.

Some suggestions to improve reproductive efficiency of cows are:

- Keep accurate breeding records of dates of heat, service and parturition. Use records in predicting the dates of heat and observe the females carefully for heat.
- Breed cows during / near the end of mid heat or heat period.
- Females with abnormal discharge examined and treated by a veterinarian
- Veterinarian to examine females not settled after these services
- Females checked for pregnancy at 45 days to 60 days after breeding
- Replacements only from healthy herds and test them before putting them in your herd.
- Have the females give birth in isolation, preferably in a parturition room and clean up and sterilize the area once parturition is over
- Follow a program of disease prevention, test and vaccination for diseases affecting reproduction and vaccinate the animals against such diseases
- Practice a sanitation program
- Supply adequate nutrition
- Provide suitable shelter management

8. Selection and Culling

Selection and culling are two sides of the same coin. Selection is the process in which certain individuals in a population are included for becoming parents of the next generation. Automatically some are excluded for the purpose which are culled. Natural selection has been going on since ages where animals which were stronger, had better survivability and were in more unison with the environment around them, found a better chance to reproduce.

Thus certain genes for certain characteristics have a better chance to be selected to form individuals in subsequent generations. Since domestication of cattle, man has been looking for superior phenotypes in traits useful to him and selecting such animals to form the parental generation. This is man made artificial selection. The manual selection process has now advances to a stage where making estimates of genotypes from the study of phenotypes and making use of that information in artificial selection has become a technical possbility.

8.1. Selection through Individual Performance Testing

There is only one way to select and that is to "keep the best and cull the poorest". Various selection methods are used as techniques for identifying or estimating genetic values of individual candidates for selection. The procedure discussed here applies to selection for quantitative trails.

Performance test is a measure of the phenotypic value of individual candidates for selection. Since the phenotypic value is determined by both genetic and environmental influences, the performance test is an estimate, not a measure of the genetic value. The occurrence of this estimate depends upon heritability of the trait i.e. on the degree to which the genetic value is modified by environmental influences.

Advantages

- Among simple procedures, the performance test is most accurate
- Environmental influences can be minimised by testing candidates for selection in the same pen or in similar environmental conditions
- The measure is direct and not on a relative basis
- All candidates for selection can be tested in contrast to progeny testing where only a parent can be tested
- Generation intervals are usually short
- Testing can usually be done on the farm under normal management conditions

Disadvantages

- Accuracy is comporomised when heretability is low
- Phenotypes are not available for one sexor in sex limited traits such as milk yield
- Traits which are not expressed until maturity may become expensive or difficult to manage by performance tests since most selection decisions must be made before maturity.

Performance tests should be the backbone of selection programs. Although much publicity has been given to other selection methods, it remains a fact that to date progress in livestock improvement has been due to selection on the individual's own phenotype i.e. performance test.

8.2. Pedegree Selection

A pedegree is a record of an individual's ancestors including its parents. This information is valuable because each individual possesses a sample half of the genes from each parent. If an individual's phenotype is accurately known, little is gained by considering pedegree in selection. Pedegree considerations are useful when there is lack sufficient accurate records of production of the individual. Also, it is useful in the early selection when the traits in question might not have expressed themselves. It is also useful for selection of males when the traits selected for are expressed only by the female such as milk production in dairy cattle.

Advantages

- It provides information when performance tests are not available for candidates
- It provides information to supplement performance test information
- It allows selection to be completed at a young age. Pedegree records may be used to select animals for performance or progeny testing in multi-stage selection scheme
- It allows selection of bulls based upon milk records of their female relatives

Disadvantages

- Accuracy, relative to alternative selection procedures is usually low
- Too much emphasis on relatives, especially remote relatives, greatly reduces genetic progress
- Progeny of favoured parents are often environmentally favoured
- Relatives often make records under quite different environments, thus introducing non random bases into the selection system

8.3. Show Ring Selection

Selection on the basis of show ring performance has had considerable value in the past. Essentially this selection has been directed towards bringing the conformation of the animal to an ideal conformation.

This improvement has been based on two goals:

- Improvement conformation
- Correlated response

Improvement of conformation has economic value because a part of the sale price is determined by conformation of the individual. The ideal type is chosen so that, in the opinion of the judges, the animal possessing this conformation is most likely to be a profitable producer. In other words, the judges are attempting to stress traits of conformation which are corrected with productive ability.

With the advent of record keeping it is found that direct selection for performance traits results in faster progress as compared to selection through correlated conformation traits. Also, when subjected to intensive study, many correlations between performance and show ring have been found to be of non-genetic origin.

If the correlations are of genetic origin, direct selection for performance should improve conformation as well as the reverse situation. The show ring has been a good forum for discussion of what constitutes ideal type and good management. It has produced dramatic changes in the conformation of some species.

Most animals which are presented in the show ring are good and selection differential among these animals is usually so small and thereby produces little change.

Advantages

- It enables breeders to exchange ideas and experience
- It allows comparisons among superior animals both within and between breeds
- It allows new breeders to make contact with established breeders

Disadvantages

- Emphasis is usually placed on traits of little economic importance
- Clever fitting and showmanship can mask defects of various kinds
- Differences between exhibited animals are usually small
- Conformation and production traits usually have low genetic correlations

8.4. Genomic Selection

Figure 13: Selecting heifers through genetics

Heifer selection begins with selecting heifers that are expected to meet the dairy herd's future goals. This usually begins with analyzing the age of heifers as older heifers are more likely to get bred earlier in their first breeding season. In addition, phenotype and structural integrity in the form of body scoring is also considered to plan for longevity in the mature cow herd. However, with emerging genomic technology, farmers can get an indepth look at replacement heifer genetic potential which assists them in selecting replacement heifers.

Genomics is a technology that uses DNA[8] information of heifers on a large scale to predict their performance at an early age. Genomic information is the analysis of an animal's DNA based on the genes it inherited from both dam and sire. Not all full siblings receive the same genes which is why they usually perform differently when put into production. Genomic data can be used to enhance Expected Progeny Differences (EPDs) and provide insight to heifer performance and maternal genetics before any progeny are on the ground.

Genomics data is generated using DNA and genomic equations which starts with collecting a blood sample, hair sample or tissue sample. The sample is collected from the area of skin after thorough cleaning process to avoid cross contamination. New tools are used always for each animal. Blood samples are usually collected from the tail or ear vein and carefully applied to a blood card for submission to the laboratory. Hair samples are taken from the tail (a good hair follicle or root bulb is needed for adequate DNA extraction) using a pliers to pull 20 – 25 tail hairs out and place directly on the plastic collection card to preserve the root bulbs. Tissue samples are commonly taken from the tip of the ear with the help of special tools.

Why Genomic Selection

Genomic selection allows better selection of replacement heifers for dairy herd having better accuracy in breeding pair selection. Since, the cost for genotyping has now significantly reduced, therefore more animals are being routinely genotyped by modern dairy farms. Genomic selection also enables farmers to select animals for the next generation of replacements within the herd rather than relying on phenotypic (observable features of the animal) assessment alone. This allows for earlier identification of elite animals within the herd and also those which are the poorest breeding animals. The use of genomic technology is becoming more widespread, enabling farmers to breed cattle according to breeding goals; for

[8] ***DNA*** *stands for Deoxyribo Nucleic Acid which is a molecule that contains the genetic code of an organisms.*

instance, breeding for higher milk yield in heifers or better fertility in young bulls. Appropriate use of genomics within herd management ultimately can lead to an increase in productivity, health and welfare, shortening the generation interval and increasing genetic improvement.

Today with the improved reliability of genetic information, the genomic testing of dairy heifers has become important in breeding and replacement strategies. By testing young heifers rather than the older animals, those with poorer genetic gains can be removed from breeding regimes and selection intensity can be increased, resulting in faster genetic gain, superior heifers and a more effective herd.

Considering the cost implications for rearing heifers, significant savings can be achieved by selling or culling the poorest animals. At a cost of approx. Rs. 6,000 per test, depending upon the service provider, genotypes can be interpreted and genomic evaluations can be conducted by international services providers (e.g. AHDB Dairy, UK[9]) which also screen for genetic abnormalities as well as give validation of parentage.

The additional cost of genomic evaluation is a considerable expense compared to other available technologies such as embryo transfer, multiple ovulation, or sexed semen, but by applying both methods it is possible to improve both profit and genetic gains. However, before genomic testing is applied on the farm it is important to ascertain which traits will be selected to achieve on farm goals. For example, selecting traits for ease of milking, condition, fertility, £PLI and lifespan.

It is recommended to select genetically superior heifers from a young age from the top 30% of the herd prior to the availability of performance records to select elite heifers to work with and also to select the bottom 50% heifers to either cull or mate with beef bulls. This will provide the most cost effective option in most cases. However, genotyping all of the young stock can be cost effective if the parentage is unknown and all of the data from testing will be used to achieve recognised on farm breeding goals. It is advisable for farmers to determine what they require from the herd in the future and identify strengths and weaknesses to make most gains.

The inclusion of testing heifers as well as genomically selected bulls enables farmers to increase the knowledge of the herd and considerably increase selection intensity. Overall genomic selection not only allows for better selection of animals for the herd but also better accuracy in breeding pair selection.

[9] *www. dairy.ahdb.org.uk/technical-information/breeding-genetics*

9. Research and Development Needs

Improvement of livestock productivity per unit animal remains the primary concern of research and development efforts. Only those breeds of livestock will survive that will be capable to produce in the changing farming systems situation. Furthermore, genetic improvement programs have to be put in place for the sustainability and development of promising breeds. Due to small herd sizes and a large number of farmers involved in livestock activities, it is generally felt that livestock genetic improvement programs developed in western countries may not be applied to Pakistan's local farming system. There is limited practical identification and production recording system in the country; thus genetic improvement programs are challenging to implement.

Major research and development needs in the area of genetic improvement of livestock are listed below:

1. Introduction of a uniform performance recording system is a basic requirement of any genetic improvement program. A low cost self-sustaining model for performance recording needs to be developed and implemented in various socio-economic and geographical locations of the country as these are used as tools for genetic improvement of animals. Alternatively, development of molecular markers for selection of animals for economic traits, at an early age, can provide an easy tool for genetic improvement. It is known that most production traits are controlled by more than one gene. However, research on genes associated with milk production and growth rate needs to be studied to develop molecular marker assisted selection in cattle.
2. There is need for evaluation and strengthening of progeny testing program of specific dairy cattle breeds (e.g. Sahiwal cow). The cost to benefit ratio for the sustainability of programs needs to be calculated. There is a need to start breed improvement programs for Kundi buffaloes and Red Sindhi cattle in Sindh province. The program must focus on involving farmers and organizing them into organization(s) that can take over this program in the long term.
3. Development of breed associations is another area for R&D in Pakistan. The interested farmers need to be organized with the Government's long term and consistent support. Initially, there is a need to start with the formation of breed associations of specific breeds such as Sahiwal and Red Sindhi cattle which may be expanded to include other breeds later on.

4. All breeds of cattle must be genetically characterized. Some of these cattle-breeds may not be economical in the changing farming system. Thus there is a need to determine genetic relationship among different breeds. Furthermore, there is a need to determine specific phenotypic characteristics of each cattle-breed e.g. disease-resistance, tick- resistance, etc. A conservation policy must also be developed simultaneously.
5. Model selective breeding programs for main cattle breeds in each geographic region must be started and supported on a long term basis. Local breeds of cattle should be evaluated for their production potential under optimum nutritional and management conditions. Those showing maximum potential for milk production may be selected for dairy parameters.

10. Bibliography

- GOP (Government of Pakistan), 2019. Economic Survey, 2019-20. Economic Affair Division, Government of Pakistan, Islamabad.
- International Trade Centre. www.trademap.org
- Afzal, M. and A.N. Naqvi.2004; Livestock Resources of Pakistan: Present Status and Future Trends. Quarterly SCIENCE VISION Vol.9 No.1-2 (Jul - Dec, 2003) & 3-4 (Jan - Jun, 2004)
- Khan. M.S., Rehman Z., etal. 2008; Genetic Resources and Diversity in Pakistani Cattle; Extension Article. Pakistan Vet. J., 2008, 28(2): 95-102.
- Luqman M. 2016. Article: US Cows make way into Pakistan's dairy market. www.samaa.tv/economy/2016/04
- John Moran. 2012: Rearing Young Stock on Tropical Dairy Farms in Asia. (Chapter 4-7). Pubiished by CSIRO Publishing, Australia.
- Dr. Farooq U. 2019-An Interview on Pakistan at risk of facing milk shortfall. Business Recorder Research. (www.brecorder.com/2019/08/19/518187)
- M. Naeem T, Riaz R. etal. 2016; Current Standing and Future Challenges of Dairying in Pakistan: A Status Update. *(www.dx.doi.org/10.5772/intechopen.83494)*
- Dairy Heifer Production. 2010, The Pennsylvania State University, College of Agricultural Sciences Agricultural Research and Cooperative Extension (www.agsci.psu.edu)
- Elizabeth Hart. 2017. Genomic selection of dairy heifers. Aberystwyth University.
- Jennie Pryce and Ben Hayes. 2012. A review of how dairy farmers can use and profit from genomic technologies. Animal Production Science, 2012, 52, 180–184 (www.dx.doi.org/10.1071/AN11172)

11. Useful Definitions and Terms

Puberty: It is a stage at which the animal becomes sexually mature and secondary sex characteristics become conspicuous. At this age of puberty, the first estrus occurs in the heifer and the bull starts producing semen with viable sperms. The reproductive organs undergo marked increase in size at the time of puberty. Under good feeding a calf attains puberty approximately at 66% of adult body size.

Sexual Maturity: It means that the animal is capable of reproduction.

Estrus Period: The duration of Estrous cycle is 21± 3 days. Pro estrus is the period of 2 or 3 days prior to estrus period. The Estrus period stays for 12 to 18 hours and Ovulation occurs 12 to 16 hours after the end of estrus period.

Genotype: It is the actual genes an organism (e.g. dairy cow) possesses for a given trait (e.g. coat colour).

Phenotype: the phenotype of an organism is physical characteristics that can be observed or measured as an individual's actual performance e.g. a 305-day milk production record or body score. There are two types of phenotypic traits — qualitative and quantitative traits.

Qualitative traits: are generally those controlled by one pair of genes, where a given genotype will typically result in the same phenotype each time. Examples of qualitative traits include gender, hair color, and horns in cattle.

Quantitative traits: are controlled by many genes. Each gene generally has a relatively small influence on the expression of a trait, but collectively, these genes can have large effects. Examples of quantitative traits include milk production, milk component percentages, and physical traits such as stature and rump angle. Quantitative traits can be significantly influenced by an animal's environment.

Useful Terms[10]

Term	Definition
Heritability	The degree to which the *phenotype* (expression of a trait that you can measure, or describe like how much milk, or what color hair) of an animal is likely to predict the expression of that trait in the offspring of the animal. How likely is it for a cow that produces a lot of milk to have a daughter that produces a lot of milk?
DNA	Deoxyribo Nucleic Acid which is a molecule that contains the genetic code of an organisms.
TPI	Total Performance Index: This is a figure which combines type, management and production traits into one number. Very commonly used to rank bulls, TPI is the USA Holstein Association's multi trait index that ranks bulls on overall performance. The traits included in the TPI formula, and their respective percentages in the formula are: • Fat 16% • Protein 27% • Feed Efficiency (FE) 3% • Productive Life (PL) 7% • Somatic Cell Score (SCS) -5% • Fertility Index (FI) 13% • Daughter Calving Ease (DCE) -2% • Daughter Still Birth (DSB) -1% • PTA Type 8% • UDC 11% • FLC 6% • Dairy Form -1%
FE	Feed Efficiency (FE) Index takes into account the individual feed costs to produce an extra pound of milk, fat and protein while accounting for differences in maintenance costs, housing costs and calving weights that may be attributed to the size of the cow. Cows that produce high volumes of milk without requiring high volumes of feed are rewarded in this index. FE = (value of milk produced) – (feed cost of extra milk) – (extra maintenance cost).
NM	Net Merit: It is economic value which is a consideration of production, SCS and PL scores and is the expected lifetime profitability of a bull's average daughter as calculated by the USDA-AIPL. The traits included in the NM$ formula and their respective percentages in the formula are: • Fat 22%

[10] *www.wwsires.com*

	• Protein 20% • Milk -1% • Productive Life (PL) 19% • Somatic Cell Score (SCS) -7% • Daughter Pregnancy Rate (DPR) 7% • Heifer Conception Rate (HCR) 2% • Cow Conception Rate (CCR) 1% • Calving Ability (CA$) 5% • Udder Composite (UDC) 8% • Feet and Leg Composite (FLC) 3% • Body Size Composite (BDC) -5%
PL	Productive Life is a score used to identify the productive days of life a cow will have compared to herd mates. A PL of 1.0 equates to one additional month of production in the herd. Only the first 305 days of lactation are included in the calculation of PL. Therefore, a lactation of 335 days in length will not receive any additional credit toward PL than a lactation of 305 days.
REL	Reliability for Production is a measure of the accuracy of the animal's production proofs (milk, fat and protein). Bulls with reliabilities between 50% and 99% are included in the top bull lists.
PTA	Predicted Transmitting Ability is the predicted difference of a parent animal's offspring from average, due to the genes transmitted from that parent. Each PTA is given in the units used to measure the trait. The PTA for milk is reported in pounds or kilograms, the PTA for productive life is reported in months.
SCS	Somatic Cell Score is calculated from the Somatic Cell Count (SCC). When milk is produced, a small number of cells, are also transferred to the milk (along with the proteins, fat, water, and minerals that make up milk). Although all milk contains some of these cells, milk quality is affected if they are present in very high numbers. Milk processors limit the amount they will allow in milk they buy from farmers. Also, knowing the SCS for an individual cow can help the farmer tell if the cow is healthy because irritation in the udder can cause higher SCS. Health management has the biggest effect on SCS, but just like some people inherit a higher chance of getting ear infections, cows can inherit traits which cause higher SCS. Next to traits like milk or protein production, SCS has a low *heritability*.
LS	Lifespan. In common with Milk, Fat, Protein and SCCs, Lifespan evaluations are also expressed as a PTA. The PTA is published in lactations with a general range of +/- 0.5 lactations. Some extreme bulls will have PTAs outside of this range. The PTA indicates the increase or reduction in lactations which daughters of a bull are predicted to survive in the herd relative to the daughters of a bull with a PTA of zero.
DCE	Daughter Calving Ease: Tendency of daughters of a particular sire to have more (or

	fewer) problems at calving time than an average cow and to produce calves that are born more easily (or more difficult) than calves produced by an average cow. measures the ability of a cow to calve easily. Each standard deviation in improvement equates to a 1% decrease in difficulty. Low Daughter Calving Ease is highly correlated with a long Productive Life.
FI	Fertility Index (FI). It combines values from three measures of reproductive performance to provide one overall fertility score. Fertility Index = 18% HCR + 18% CCR + 64% DPR
DPR	Daughter Pregnancy Rate measures the cow's ability to begin cycling, show estrus, conceive and maintain pregnancy and is highly correlated with PL. A DPR of 1.0 equates to a 1% increase in pregnancy rate during a given 21 day estrus cycle. Each increase of 1% in PTA DPR equals a decrease of 4 days in PTA days open. For example, daughters of a bull with 3.4 DPR will get in calf 13.6 days quicker on average than a bull with a DPR of 0.
HCR	Heifer Conception Rate: the PTA HCR measures the ability of virgin heifers to conceive. An HCR of 1.0 equates to a 1% increase in heifer conception rate.
CCR	Cow Conception Rate: the PTA CCR measures the ability of lactating cows to conceive. A CCR of 1.0 equates to a 1% increase in cow conception rate.
SCR	Sire Conception Rate: this is not a genetic trait but measures the fertility of the bull. The SCR of 1.0 indicates a 1% increase in conception rate when compared to average.

12. Useful Links

Genomic Assessment Service Providing Compnies

- MM Corporation Pakistan
  Gold Mine Plaza ,Ferozpur Road, Lahore.
  Contact No. 0423-7502020

- Innovative Business Solution
  46- Jahanzeb Block, Allama Iqbal Town, Lahore.
  Contact No. 0300-4028728

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