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Review Article

An Overview of Chicken Reproductive Performance and its Challenges at High-Altitude of Leh-Ladakh Region: Review

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Abstract

Poultry industry is rapidly increasing worldwide and India is seen as a prominent market for both chicken broiler and chicken egg production. There are number of states in India, especially from its southern part which play an important role in increasing countries GDP from the poultry industry however, the scenario is still very gloomy from Leh-Ladakh region. Ladakh comes under high-altitude region which is around 3500 meter above mean sea level, characterized by harsh environment i.e. low oxygen, low atmospheric pressure, low temperature, high wind velocity followed by extreme winter. This stressful condition hinders the health and productivity of poultry chicken. The purpose of the present review is to overview the overall reproduction and productive phenomenon of hen and challenges of poultry farming at high-altitude. Emphasis is given on how the production performance of chicken can further be increased at such stressful environmental condition which will be very helpful to the local progressive farmers interested in poultry backyard farming in this region in future.

Keywords: Chicken; Reproduction; Productivity; High-Altitude; Challenges; Ladakh

Introduction

The history of poultry rearing in India is some 5000 years old. Chickens were suggested to have originated and domesticated from Red Jungle Fowl (*Gallus gallus*), the bird that is still known to dwell in the wild in most of southeast Asia [1] and is suggested to have originated from Southeast Asia [2]. Although the monophyletic or polyphyletic origin of chicken is still to be debated, the more favoured by scientists is its monophyletic origin against the polyphyletic origin [3]. The poultry industry has so far been seen as a promising sector across the globe and also in India in particular. In the past couple of decades, the poultry industry has undergone enormous changes in terms of its operation and structure. Earlier, it was confined to backyard farming only but now it is flourishing and has manoeuvred towards an agri-business with an annual turnover of Rs 49000 crores [4]. According to the 19 livestock census, around 30 million farmers are engaged in backyard poultry farming. The eggs and meat are sold at higher prices in rural and tribal areas as compared to urban areas and therefore necessity and chances of growing backyard poultry in rural and tribal areas are more.

Improvement and growth in poultry farming are being brought about and are currently dominated by the commercial sector on a large scale which is mostly private and that controls roughly about 80% of total Indian poultry production. One of the reasons that the poultry industry is flourishing could be that when other nutrient-rich foods are costly and seasonal or not available throughout the year in some places; eggs and chickens are available and accepted by people of almost all communities across the country. On the other hand, chicken and poultry meat are cheaper as compared to mutton and fish and its consumption is also growing at a faster rate. The poultry sector also seems to obtain a large regional acceptance. Nearly 70% of the population lives in rural areas of India and just 25% of the population living in India was studied to consume about 75-80% of eggs and poultry meat [5]. Even processed chicken meat is now being accepted by people all over, and understanding the requirement for hygienic and safe food, it now looks more hopeful for a bright future for the processing industry. Ali [4] also suggested that processed food attracts attention and its market is rising at a phenomenal rate. It provides not just food but also offers opportunities to entrepreneurs all over and India is now setting itself as the world's "food factory".

Status of poultry industry in India

With the population increasing at a fast rate, the nutrient requirement in form of poultry products mainly egg and meat are also high in demand. The poultry sector in India is divided into two sub-sectors unorganized sectors (about 20% of total market

share) and organized sectors (about 80% of total market share) and in general, is valued at about Rs 80,000 crore in the year 2015-2016. The majority of the poultry production is accounted from the southern part of India i.e Andhra Pradesh, Kerala, Karnataka, and Tamil Nadu [4]. A steady increase in poultry egg production was observed up to the year 1999-2000 and from there onwards it improved substantially to reach 69.73 billion in the year 2012-13 [6]. According to a poultry sector report, broiler meat production has increased to 4.2 million tons per annum in the year 2015-16 and the total layer production has gone up to 80 million eggs per annum. The population of poultry was increasing at a faster rate as compared to other livestock increases in the same year, 2019. The poultry population stood at over 851.8 million across India, while this number was about 535.8 million for livestock in the same year. The poultry sector grew and developed more as compared to the livestock sector, in the year 1951 where the poultry production was 73.5 million, doubled by the year 1972 which was 138.5 million and it then reached 489 million in 2003. The increasing trend of poultry is shown in table 1 [7].

Common exotic and indigenous breed of chicken reared in India

Through various rigorous genetic selection programs, many improved stocks are being developed either as pure lines or hybrids. Today's improved stocks of chicken use exotic breeds like Leghorn and Rhodes Island Red as egg-producing stock whereas Cornish and Plymouth Rock as meat-type stock. But this process of developing high-yielding and better-performing germplasm has overlooked and ignored the potential of genetic resources of native breeds and also has extended at the cost of the native population of poultry resulting in a massive threat to the loss of native genetic diversity [3]. The native breed of chicken is slow-growing with a poor feed conversion ratio (FCR) but they are often accepted and preferred for the better quality of meat which also brings about higher prices as compared to commercial broiler chickens which are mainly hybrids of exotic chickens and are fast-growing with high feed conversion ratio (FCR) [8]. Native breeds are rather poor in egg production (annual egg production: 50-60 nos), and their contribution to the total egg output was almost static for the last few decades [9]. Nevertheless, native chicken meat has more value among rural and urban people for both the rich and poor as compared to the ones produced commercially.

Rearing a good quality chicken breed is a must for a healthy industry and farmers are opting for the native chicken because of its performance, ability to thrive in harsh conditions, and quality of its meat and eggs [10]. Based on the performances and the phenotypic characters 19 native breeds of chicken were registered in India till 2019. These included Aseel, Ankleshwar, Busra, Chittagong, Daothagir, Denki, Ghagus, Haringhatta Black, Kadaknath, Kalasthi, Kashmir faverolla, Miri, Punjab Brown, Tellicherry, Nicobari, Hansli, Uttara [11]. Not many studies about all the native breeds have been done and there is a limited source of information about all the registered indigenous breeds of India. The breed registration committee approved the registration of the 20th indigenous breed of chicken "PD2" (Vanaraja female) developed by ICAR-DPR, Hyderabad in January 2020. The list of indigenous breeds of chicken is depicted in table 2 [12].

Reproduction system in chicken

Reproduction is the foremost vital system of all breeding livestock and chicken has a unique reproductive system. Its uniqueness is reflected in maintaining several of its functions including the sperm storage in the female sperm nest, and fertilization of eggs using these stored sperms, and hormone production. Avian species, in general, have adopted a variety of reproductive strategies allowing them to reproduce under diverse environmental conditions. Environmental and behavioural components of reproduction are regulated by the hypothalamus in response to various environmental factors such as photoperiod, temperature, and internal factors such as the stage of a bird's lifecycle and its health conditions [13].

In all birds, the females are the heterogametic sex (ZW) and the males are the homogametic sex (ZZ), unlike many other livestock animals. Sex determination and differentiation of the male testes are attributed to a dosage effect related to the DMRT1 (double sex and mab-3 related transcription factor 1) gene, double sex, and mab-3-related transcription factor. These genes are Z-linked and are supplemented by another Z-linked gene that encodes hemogen protein (HEMGN) and the default sex is female in the absence of this gene dosage effect [14]. At day 3.5 of gonadal sex determination in the chicken embryo, the primordial gonads are evident on the ventromedial plane of the embryonic kidneys. At this point, the gonad is still not differentiated and it comprises an outer cortex and underlying medulla. Mesenchymal cells are dispersed between the cords in the medulla. Primordial cells are present primarily in the cortex. Morphological differentiation starts between 5.5 to 6.5 days. In ZZ embryos, bilateral testis differentiation happens, in ZW only the left gonad makes the ovary and the right one regresses. Medullary cords give rise to seminiferous cords during testes formation but it breaks up and develops lacunae in the developing ovary. The cortex reduces in developing testes but thickens and multiplies in the ovary. It is considered important to study the female bird reproductive organs from an economic point of view as well as total egg production.

Female reproductive system

Chicken and most of the avian reproductive system consist of an ovary and oviduct. In female birds, ovaries are present cranio-ventrally to the corresponding kidney and both the left and right ovaries are present in the embryo but in chickens, geese, and turkeys

the right ovary regresses in adults. Both ovaries start to grow after around 72 hours of incubation in the chicken. Estrogen plays a crucial role in the process of sexual differentiation, secondary sexual characteristics of the female, and vitellogenesis [15]. After the 6th day, the outer cortex of the left ovary grows even larger and more noticeable while the right ovary starts to regress. Larger germ cells formed by oogonia were found in the left ovarian cortex. The reproductive organ of the DIHAR line hen is depicted in Figure 1.

Ovary

The ovary of a chicken resembles a cluster of grapes in its shape and is composed of ovisacs in different stages of its development. Ovum (singular form of ova) initially starts as a single cell and is enclosed by a vitelline membrane. The follicle constitutes a primary oocyte which is surrounded by six layers of tissue. The size of the organ varies with the reproductive status of the bird [14]. In a hatched chick, more than 12,000 oocytes are already present and the number doesn't increase once the chick is hatched out. Of these many thousands of oocytes, only a few numbers will acquire yolk and then develop into mature oocytes. Only a few oocytes of the total present at the time of hatch (200-500) reach maturity and are ovulated. In a sexually mature hen, follicles grow in a hierarchy of small undeveloped to large follicles that are ready to ovulate. The ovarian follicular development in chickens is a continuous process right from the activation of small cortical follicles to the ovulation of the follicle highest in the hierarchy [16]. This hierarchy includes primary follicles, pre-hierarchical follicles, preovulatory follicles, post-ovulatory follicles (POFs), and the mature follicle which is some 400 times larger than the primordial follicles [17]. As the small follicle increases in diameter, the yolk starts getting visible and thus is categorized into a hierarchy [13]. Histological studies of the ovary showed that on the first day after hatching, it has a smooth surface and the parenchyma and the vascular areas are not delimited whereas, at 126 days from the hatching, the ovary is completely formed with a prominent interstitial gland.

The left ovarian cortex had large clusters of germ cells formed by Oogonia and Oocytes surrounded by flattened pre granulose cells with a scanty cytoplasm. Both left and right ovaries had a compact medulla with moderate vasculation and large lacunar channels. A sequence of complex biochemical and physiological changes takes place during the growth and development of the ovarian follicle. These changes comprise the expression of gonadotropin receptors, steroid biosynthesis, cell proliferation, and differentiation [15]. Extracellular matrix (ECM) degradation and remodelling are some of the key regulators of cell growth, proliferation, and differentiation. It is required to be done as all cells in the body are surrounded by an extracellular matrix. The parenchyma and vascular areas are distinctively delimited with a ratio of 6:1 [18].

Oviduct

Most avian right oviduct regresses as the bird grows and only the left oviduct remains functional which is then responsible for the formation of the shelled egg. A fully developed oviduct is a twisted tube-like organ that is 25-27 inches attached by the mesotubarium ligament to the dorsal body wall. Inconspicuous straight narrow tube in immature and non-breeding hens whereas, in the reproductively active hen it undergoes several changes and enlarges to occupy a huge portion of the abdominal cavity. The oviduct causes a folding itself due to an increase in its length [19]. It consists of five different segments that can be distinguished histologically and each segment plays a role in the development of the egg. These segments are the infundibulum, magnum, isthmus, uterus/shell gland, and vagina in a distal to the proximal direction. The ova/yolk passes through the oviduct following ovulation and in each segment of the oviduct is secreted and deposited the various constituents of eggs. As the yolk enters the oviduct, it takes around 24-28 hours before a complete egg is formed.

- **Infundibulum:** The first segment where fertilization takes place is 3-4 inches long [20] and constitutes two parts, a thin-walled tube that releases into a thick-walled tube [19]. It encloses the ovary and is distinguished as a membranous infundibulum that covers the ovarian clusters and a muscular infundibulum having ciliated cells that function as a passageway for the yolk inside the oviduct. The egg remains here for 15-30 minutes. The ovulated egg is grasped by the funnel but not all ovulated eggs fall correctly into the infundibulum, some are lost into the body cavity. Sperm penetration occurs here and also in the inner part of the chalaziferous layer and the chalaza is formed from the infundibulum [21].
- **Magnum:** Magnum is where the albumen is deposited over the yolk and is the largest segment of the Oviduct. It is around 13 inches long. Magnum can be differentiated from infundibulum by its structural nature i.e., coiled with a wider diameter. This part is also thicker by the presence of various glands in it [19]. Egg white proteins are synthesized by the glandular epithelial cells and are secreted only for 2-3 hours as long as the egg remains here.
- **Isthmus:** It is the bridging part between the magnum and the shell gland. Outer and inner eggshell membranes are formed over the egg white albumin in this segment. Isthmus has two parts in it, the upper white part and a lower part which is red, from where the inner and outer shell membranes are further added respectively [19]. The initiation of eggshell mineralization also takes place in Isthmus. The egg remains here for 1-2 hours [20].
- **Eggshell gland:** Once the egg is enveloped by the eggshell membrane it moves down into the shell gland and then remains there for the longest duration (18-22 hours). Calcite

crystals are deposited to form the eggshell in this segment of the oviduct. Eggshells constitute 95% calcium and are the key source of calcium for the embryo [20].

- **Vagina:** Once the eggshell is deposited and mineralization is completed, the egg remains for a short period in the Vagina [20]. Birds have a special gland that can store sperm for 10-14 days inside the female body. This sperm storage tubule (SST) is located at the intersection of the vagina and the shell gland [19].

Factors affecting egg production

Poultry egg production depends on not just the hen's genetic factors but also on various environmental factors as well, like climatic conditions, housing, feeding management, stock density, photoperiod, age of the bird, breed, and disease control. Some of the common factors affecting egg production are listed below.

Age of birds

Age plays an important role in the egg production efficiency of laying hens. Egg production usually increases in the 6^{th}- 8^{th} week after the laying has started which is maintained for a couple of months and thereafter it gradually decreases with lesser egg production in old age as compared to young age. The reduced ovulation rate and increase in the size of the follicles ovulated in older birds are thought to be associated with a reduced rate of recruitment of follicles and an extended period of follicular growth and development [22]. The age of the birds is also an important factor that affects the egg albumin quality of the egg. It was observed in a study conducted by Peric., *et al*, [23] albumen height, Haugh unit (HU), and eggshell quality of laying hens decrease with the age of the birds. This decreased shell quality could be due to an increase in the weight of eggs without an increase of the calcium carbonate that is required and deposited in the shell [24].

- Age of laying hens significantly increased egg weight, incidence of pimpled or speckled eggs, star- or hair-like cracks, and meat spot. O

Temperature

Generally, feed intake and egg production efficiency decrease with extreme temperature rise. Aduli., *et al*, [25] reported the thermoneutral zone for optimal egg production to be 12.6–20.0ºC. The low environmental temperature was also observed to affect egg production and temperature below 16 degrees reduces productivity and may show various other negative effects like reduced nutrient digestibility, increased feed intake, and reduced egg production [26]. It was observed by Li., *et al*, [26] that low ambient temperature also reduces egg quality traits (low albumin height, yolk weight, and haugh unit) and shell quality traits (shell weight, shell thickness). Birds, specifically the layers reared under cold conditions lose 4 times more energy than what is recommended to maintain their body temperature, due to their less capability of feed intake the birds are not able to increase the metabolic energy required to maintain their body temperature and egg production [27].

Housing management

The housing system in poultry is one of the major external factors that influence the performance of hens as well as the egg quality [28]. According to Anderson and Adam, [29], eggs produced by chickens that are being raised in cages are heavier and are more accustomed to handling as compared to the ones which are raised in floor pens. The deep litter floor system fulfils many of the bird's requirements, it has a litter for dustbathing in it, scratching and pecking, and laying nests are also made available in the pens. However, the deep litter system lacks behind in several other aspects like housing density, labour cost, efficiency, and manageability. Birds reared in deep litter showed higher feed intake resulting in better egg production and a higher period as compared to the birds that were reared in a cage system. Floor systems when maintained and managed properly proved to provide the optimization of egg production and the egg-laying rate was higher in floor-reared birds [30]. Various egg quality characteristics were observed to be better in caged laying hens than in other housing alternatives. These eggs had higher Haugh unit values, and albumen and yolk indices were also high in the eggs that are laid by hens kept in a cage [29]. The level of microbial contamination of the egg also affects the egg quality characteristic and this level of contamination by bacteria depends upon the type of housing that hens are being reared in and is then related to temperature and humidity [28].

Photoperiod

Light is another important environmental factor in poultry and it not only provides illumination but affects various physiological functions and behaviours in poultry birds. It was observed that photoperiod acts on a bird's circadian rhythmicity [31]. Birds kept under a light period for 16 hours were observed to produce more eggs as compared to the ones that were illuminated for 18 and 20 hours [32]. As opposed to mammals, birds have retinal photoreceptors responsible for vision and extra-retinal photoreceptors for photoperiod detection and synchronization of their physiology to the environment [33]. The eye, pineal gland, and hypothalamus are the three main organs that have these photoreceptors [34]. In poultry, extra-retinal photoreceptors were observed to be more stimulated by higher light wavelength than the lower light wavelength and this promotes their reproduction [35]. Light of different wavelengths also showed different effects on the laying hens. Various artificial lighting is being used to improve the bird's performance in poultry.

Feed additives

It has been observed that amino acid balanced feed supplement

improves the performance of a laying hen to a significant extent and also increases clutch length as compared to birds that are fed identical supplements without the required amino acid balance [36]. These various products obtained from plant sources have been called "Phytogenic feed additives [37]. They are well-defined as compounds having plant origin that are incorporated into animal feed to improve livestock productivity by improving their digestibility, nutrient absorption, and eradication of pathogens that reside in the animal gut. Phytogenic additives are being used to improve performance in production, egg quality, FCR, and other functions. The stimulatory effect of these additives is due to the improved palatability of the diet that results from the better and enhanced flavour, odour and thus resulting in overall improved performance [38]. The use of these products in poultry and animal nutrition is preferred over traditional antibiotics, probiotics, and prebiotics.

Artificial Insemination in chicken

Artificial Insemination (AI) is a technique of injecting semen into the uterus or vagina. This technique was started to implement in humans as well as in animals. The prime reason for using this technique was for the genetic improvement of the livestock. The highly selected male chicken is mated with several females to achieve the best-performing offspring. Better fecundity was obtained in many instances by artificial insemination as compared to natural mating. In Isreal, 40% of all hatching eggs were collected from artificially inseminated females [39]. Australia also started following AI in its commercial poultry farms followed by the USA. Kharayat., *et al*, [40] stated in their study that artificial insemination was first started in America in the 1920s and Australia adopted the method in the 1950s. Successful implementation of this technique requires good semen to be inseminated near the sperm storage glands present in the female. The average volume of semen required is between 0.05-0.50ml in light chicken breeds and 0.1-0.9ml in the heavy chicken breed [41] and 100-200 million spermatozoa/insemination [40], and one ejaculate can cover upto 20 female birds by AI. Several factors influence semen quality and sperm motility is one of the main factors that determine fertility in fowl. Another factor is the visual examination of semen. Domestic fowl semen typically needs 2-3-fold dilution. The semen collected needs to be stored at 2-8 degrees celcius for avian species [41]. According to the Animal Husbandry report of Tamil Nadu Agricultural University, the dose of semen for chicken should be .05ml and should be performed once a week.

Besides the benefits of AI over natural mating, the implementation of this technique is limited to research purposes. There are other advantages of artificial insemination including more settable eggs, improved fertility, and hatchability [42]. Normally one fowl can naturally mate with up to 6-10 females but with the implementation of this method of AI, this ratio can be increased four times. Males that show better performance can be used to mate for several generations unlike in natural mating where their use is limited. Male birds with physical injuries especially in the leg can still be used to inseminate females.

Burrows and Quinn [43] described a method of collecting semen and inseminating it into the female's vagina. It is suggested to not feed the birds for 12 hours before collecting semen because the phallus and the anus are located in the same duct and continuous feeding up to the time of semen collection increases the chance of contamination. Once the semen is deposited in the female's reproductive part, it will enter the sperm storage gland present at the junction of the Vagina and the shell gland. The spermatozoa will move up to the next site near the magnum and infundibulum [44]. According to a study conducted by ICAR 0.5ml semen constituting 5.34billion sperm/ml can be inseminated into 110hens /male and that can be achieved after the semen is diluted (1:10) [45].

Poultry at high altitude

Regions from 2500mtr to 6000mtr above mean sea level are considered an area of high altitude. In high altitudes, harsh environmental conditions prevail followed by high UV radiation, hypoxic conditions with a low partial pressure of oxygen, high wind velocity, low relative humidity, extreme temperature variation (+30 to –30°C), low precipitation, and snowfall. Due to these conditions, it becomes difficult for any living creature to survive and lead a normal life. Therefore, there's a very low population of animals and humans dwelling at such heights. It is reported that in Himalayan ranges, bird populations and the number of species are very low. No native breed of chicken is found in Leh region now, which is located at an altitude of 3500mtr above mean sea level. There are few studies on the high altitude adapted native chicken breed of Tibet which is known as Tibetan chicken. This chicken resides at an altitude of 2200-4100 meters above mean sea level and has already developed an adaptive mechanism that allows them to cope with hypoxia. This was proved right by their high rate of hatchability and better survivability in the region as compared to other breeds of chicken [46]. Tibetan chickens are a breed of chickens that are living at high altitudes for the very longest time in the whole world [46]. Some of the unique characteristic features developed by the high altitude adapted breeds are high affinity of O_2-hemoglobin, absent or moderate polycythemia response, low venous pO_2, and absence of mountain sickness. No studies have been conducted on the chicken's reproductive performance so far in the region of Ladakh. Although few preliminary studies from our lab on growth performance have been done in high-altitude areas, nothing is reported about the reproductive performance of chickens at high altitudes so far. Ladakh currently doesn't have its native breed of chicken which makes it more important to study the physiological changes that the altitude brings about in chickens and their production performances in the region.

Egg production at high altitudes

High altitude has an adverse effect on overall health and production performances of poultry. Due to extreme environment characterized by hypobaric-hypoxia, the total egg production of hens is compromised which causes economical loss to the farmers. Earlier, it has been reported that the egg production rate reduces at high-altitude, even the hen starts laying eggs late as compared to a hen from the plain region of the country. Schematic representation of high-altitude environmental challenges and its effect on chicken reproductive performance is depicted in Figure 2. Different forms of egg collected from DIHAR line chickens are presented in Figure 3.

Ways to increase egg production at high altitudes

- **Proper feeding:** Feeding ad-libitum at a young age as well as during sexual maturity is observed to harm production; it could cause lifetime obesity, discomfort, and poor control over ovarian follicle production as well as its release. Supplementing the right nutrients and other feed supplements before sexual maturity could also enhance production in the hen. Vitamin D also makes one of the important supplements for laying hens. Vit D is found in two forms, D2 and D3, and is equally important in most animals but in birds, Vit D3 is more active than D2. Similarly, Calcium forms the eggshell and its requirement increases as the hen reaches sexual maturity. Therefore, a calcium supplement is also necessary to improve hatchability [47]. Among other elements selenium and boron are also found to be involved in chicken reproduction and bone metabolism. In high altitude regions like Ladakh it becomes more important to take extra care of proper feeding and supplementation to the chickens.
- **Photoperiod:** Some regions of the high-altitude area have short day lengths resulting in insufficient photoperiod for layer hens. Delay in photo-stimulation led to a delay in sexual maturity and as the photo-stimulation occurred acceleration in sexual maturation was observed. Birds kept under a light period for 16 hours were observed to produce more eggs as compared to the ones that were illuminated for 18 and 20 hours [48]. Therefore, maintaining 16hour light and 8 hours dark is recommended in high altitudes.
- **Proper male: female ratio:** The presence of cock is shown to affect both egg production performance and hatchability [49]. Thus, maintaining a proper ratio of males to females is important. Although increasing the ratio from 1:12 to 1:18 increases egg production it decreases the fertility of the egg. Therefore, to obtain a fertile egg it is advisable to reduce the ratio of male to female. There is no reported data available about the proper male to female ratio in high-altitude.
- **Selection of breed:** Based on physical characteristics like comb, wattles, and distance between pubic bones, good layers can be selected and the poor ones need to be culled off to obtain and good performance result. A good layer possesses smooth and waxy combs and wattles and the pubic bones are flexible. The distance between two pubic bones should be a minimum of three fingers [50]. Therefore, selecting the best female layer as well as the best male is a crucial step. Selecting hardy breeds that can survive harsh climatic conditions will be best suited for the high-altitude adaptation.
- **Selective breeding:** Selective breeding is done worldwide as per the requirement of the breeder. A good layer, disease-resistant, and rapid grower are some of the characteristics that are being looked for and birds are bred accordingly. The red jungle fowl presumed ancestor of the current domestic fowl is known to lay 10-15 eggs per year in the wild while today's hens lay an average of 266 eggs annually [51]. Therefore, selective breeding of the best-adapted and better-performing breed is essential to further rear them in the area.
- **Genetic modification:** Genetic selection is of prime importance if we want a better performance in case of any traits like growth and production. Over the past 60 years, a great amount of development in the poultry sector in terms of attaining rapid growth and decreased slaughter age by increasing meat yield has been obtained. Progress has also been observed in the reproductive performance of the female lines in the past years as a result of which the average egg production of 155-160 eggs per hen housed to up to 60 weeks of bird age has been attained [52].

Conclusion

The demand for fresh chicken meat and eggs is increasing day by day in Ladakh region due to high tourism and the gap between the demand and supply should be narrowed by identification and selection of best performing chicken breed at high-altitude in context of both egg production and growth performance. Egg production depends on number of factors and the scenario even changes more at high-altitude harsh environment. The present review mainly focuses on such factors and challenges of poultry rearing at high-altitude and provides an overview in tackling those challenges. Successful poultry rearing and fulfilment of fresh chicken meat and egg is need of the hour now for both consumption and economic upliftment point of view throughout the year in Ladakh region.

Year	Poultry (in millions)
1951	73.5
1961	114.2
1972	138.5
1982	207.7
1992	307.1
2003	489
2007	648.8
2019	851.81

Table 1: Poultry status in India.

S. No	Indigenous breed	State
1	Ankleshwar	Gujarat
2	Aseel	Chattishgarh, Orissa, and Andhra Pradesh
3	Busra	Gujarat and Maharashtra
4	Chittagon	Meghayala and Tripura
5	Daothagir	Assam
6	Denki	Andhra Pradesh
7	Ghagus	Andhra Pradesh and Karnataka
8	Haringhatta Black	West Bengal
9	Kadaknath	Madhya Pradesh
10	Kalashthi	Andhra Pradesh
11	Kashmir faverolla	Jammu and Kashmir
12	Miri	Assam
13	Punjab brown	Punjab and Haryana
14	Tellucherry	Kerala
15	Nicobari	Andaman and Nicobar
16	Hansli	Orissa
17	Kaunayen	Manipur
18	Uttara	Uttrakhand
19	Mewari	Rajashthan
20	PD2(Vanaraja Female Line)	ICAR-Directorate of Poultry Research, Hyderabad

Table 2: Registered native chicken breeds in India.

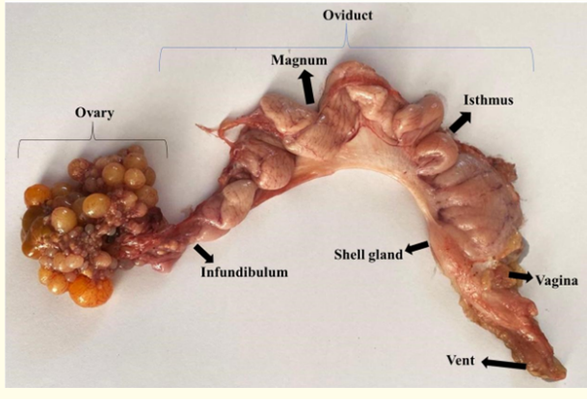

Figure 1: Reproductive tract of Female chicken.

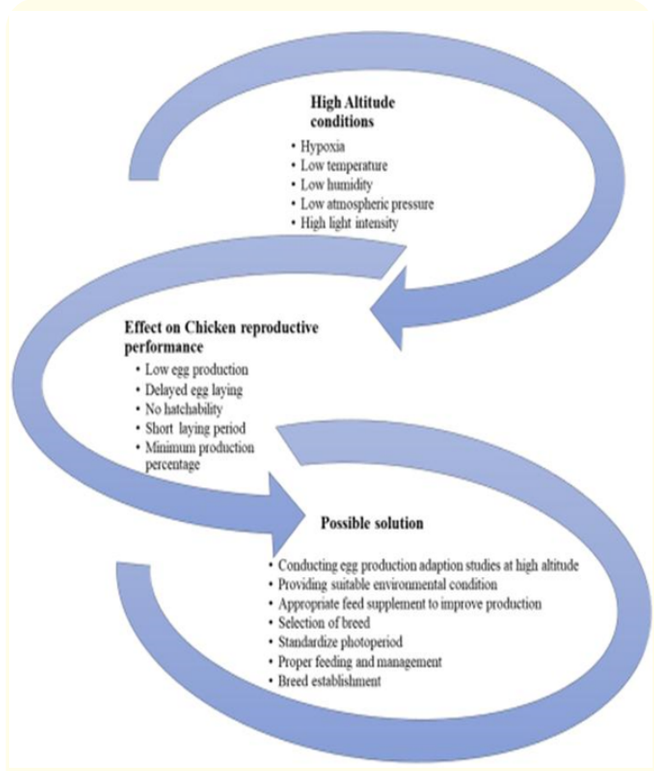

Figure 2: Schematic representation showing effect of High-altitude on chicken's reproductive performance.

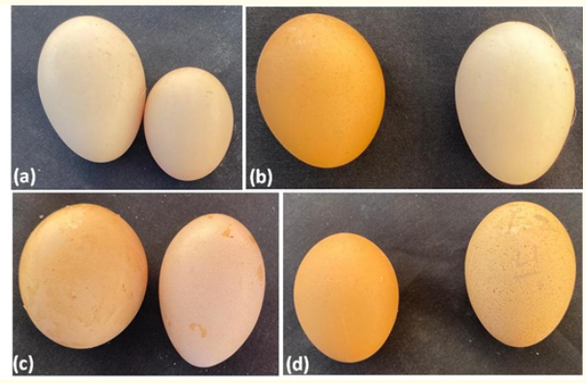

Figure 3: Different forms of chicken eggs (a) Different egg sizes; (b) Different eggshell colour; (c) Different egg shape; (d) Different spots on eggshell.

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