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RESEARCH ARTICLE

CURRENT STATUS AND FUTURE PROSPECTS OF ARTIFICIAL INSEMINATION IN GOATS IN NEPAL: A REVIEW

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ABSTRACT

Nepal is endowed with several indigenous, exotic, and crossbred goat species and breeds that carry potency to contribute a far more to agricultural production than they are presently contributing. Low productivity and high demands of goats have been prevailing in Nepal for a long. Detailed knowledge about various biotechnological procedures like artificial insemination (AI) for breeding is vital in managing goat for high reproductive rates and increasing productivity. Problem of inbreeding in goat exists in farms of Nepal. Thus, Goat farmers can use AI for genetic improvement in their herds. This review aims to provide sufficient knowledge about AI in goats, its prevailing condition, and prospects in Nepal. It also aims to disseminate knowledge about reproduction in goats, oestrous synchronization, and many other factors related to AI. Findings revealed that AI is currently being practiced in Nepal to improve flock productivity and carries huge scope for the future too. However, the present status of AI was found unconvincing. The conception rate was just 35% with total 4,499 AI in goats in 2018/19, and the coverage was less than 1%. Studies also showed that the facilities for semen collection, processing, preservation, and storage are available in Nepal. But a huge amount of semen is still being imported because of insufficient technologies here. Limited researcher related to AI in goats in Nepal is also a hindrance to develop AI in goats in Nepal. It is better to conduct a detailed study on AI in goats in Nepal to help farmers, traders, and planners.

KEYWORDS

Biotechnology, Conception, Productivity, Semen.

1. INTRODUCTION

Nepal is no doubt an agricultural country, whereby the maximum number of people sustain their livelihood employing agriculture which contributes to about 24.26% of national gross domestic product (Statista, 2020). The contribution of livestock to national GDP as well as agricultural GDP is significant. Goat (*Capra hircus*) is the most admired small ruminant of Nepal, which is quite easy to handle and care as compared to other livestock and is also preferred as they provide manure to crop production along with a supply of milk and meat. There is a consistent and ever-growing demand for goat's meat as it is considered as elite meat in Nepalese culture (Yadav et al., 2019). They are also referred to as "poor man's cow" in Nepal. Besides providing employment opportunities, it also acts as a safety against crop failure and has religious significance. In 2018, Nepal secured 21st position in goat farming in the world with a goat population of 11,647,319 (FAOSTAT, 2020; MoALD, 2020).

Only 40,576 goats were exported from Nepal in 2018 which was equivalent to 155,000$ (FAOSTAT, 2020). Among Nepal's natural gifts are the diversity of climate and varied topography making it suitable for, among many others, goat production. Chyangra, Sinhal, Khari, and Terai are the four indigenous breeds of goat in Nepal distributed from plains to mountains whereas, the popular exotic breeds are: Jamnapari, Barbari, Sirohi, Boer, Saanen, and Beetal (Bhattarai et al., 2020). Possessing a huge scope of goat production, Nepal is still lacking behind other countries and not being able to meet global demand because of a lack of biotechnological procedures to multiply goats. Farmers identified inbreeding as a key issue with goats, which can be addressed through goat breeding programs (Redding et al., 2012).

Reproduction is critical to the success of any livestock enterprise, including goat farming. Various attempts are being carried out across the globe to multiply goats by the application of reproductive biotechnology. A suitable breeding practice is the utmost to improve flock productivity and gain a myriad of profits. For this purpose, Artificial insemination (AI) has been proven as one of the best breeding practices showing prodigious improvements in both genetics and reproductive management of goats (Bhattarai et al., 2020). AI is the fertility treatment and is the common practice in animal breeding carried out by the deliberate introduction of semen into the vagina of suitable doe to achieve a pregnancy through in vivo fertilization. In addition to natural, traditional mating, AI has gained popularity among goat breeders, as it allows easy access to a wide variety of bloodlines. It involves the collection of male gametes (sperm cells), their evaluation at the cellular level for fertility parameters, processing in an artificial medium (dilution or extension), cooling and freezing for preservation, thawing, and insemination proper in the recipient female (Paudel et al., 2007).

An adequate understanding of these tools cannot be overemphasized and must be carefully implemented to ensure breeding success. Sufficient effort is necessary to increase the goat production to reduce the import, accelerate export, and generate a huge amount of national revenue, which can be achieved by improved breeding and other husbandry practices (Bhattarai et al., 2020). The objective of this review is to describe artificial

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insemination techniques in goat, it's prevailing conditions, and prospects in Nepal with respect to all the AI related factors to enhance the reproductive performance of goats, multiply goat populace, and ultimately contribute to global food security. This will also help farmers, traders, as well as policymakers.

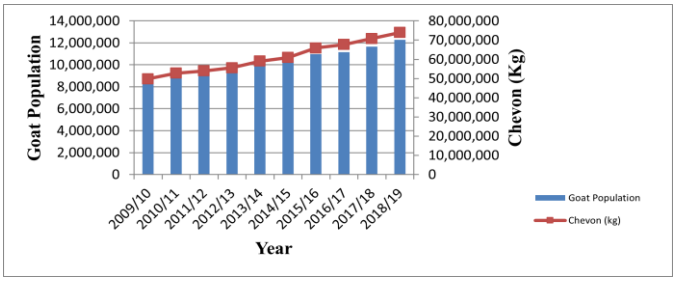

Figure 1. The trend of goat population and chevon production in Nepal over ten years (Source: MoALD, 2020)

2. METHODOLOGY

Required details and facts were gleaned via literature that includes journal articles, websites, conference proceedings, governmental publications, and other annual reports. Further information on artificial insemination was collected. Summarizing these data, facts, figures, etc., graphs were generated using excel, and a conclusive outline of the artificial insemination was drawn.

3. RESULTS AND DISCUSSIONS

3.1 Reproduction in goats

Does are polyoestrous animals whose reproduction are narrated as seasonal i.e., the onset and extent of the breeding season is conditional on several factors such as climate, breed, health, presence of the buck, the system of breeding, and precisely photoperiod (Fatet et al., 2011). The doe arrives at pubescence between 5 to 7 months old enough, contingent upon the variety, period of birth, level of taking care of/nourishment, and in general wellbeing status (Jainudeen et al., 2016). Pubescence is believed to arrive when the female displays her first warmth (estrus) and ovulation. Control of procreation by hereditary, physiologic, and ecological techniques could expand the recurrence of rearing every year and the litter size in these species (Jainudeen et al., 2016). Estrus, or warmth, is the period where the doe will stand and permit the buck to raise her. This period of the conceptive cycle may last between 24 to 48 hours. The period starting with one warmth cycle then onto the next is alluded to as the estrous cycle. Copulation occurs during oestrus, therefore usually before ovulation, and implantation of the embryo is observed 18–22 days after the onset of oestrus (Fatet et al., 2011). Nutritional strategies can also manipulate the estrous cycle and affect doe's reproductive performances (Fatet et al., 2011). The gestation period of the doe ranges between 145 to 152 days, or 150 days on average (AITC,2020).

Table 1: Reproductive parameters of goats (doe and buck).

Reproductive parameters	Doe	Reproductive parameters	Buck
Age at puberty (months)	5-7	Age at puberty (spermatogenesis) (months)	4-6
Estrous cycle length (days)	21 (18-22)	Sexual season	none
Estrus (hours)	24-48	Duration of seminiferous epithelial cycle (days)	_
Ovulation (No. per cycle)	2-3	Semen volume (ml)	0.1-1.5
Life span of corpus luteum	16	Concentration (billion/ml)	2-6
Mating (male:females)- 1:50			

(Source: Jainudeen et al., 2016)

3.2 Oestrus synchronization

Estrus synchronization empowers concentrated breeding that guarantees uniform kid development and appropriate administration of pregnant does (Omontese, 2018). Enabling all the does to come to heat simultaneously by some sort of manipulation in their estrous cycle, is commonly known as oestrus synchronization. It permits the farmers to shorten the rearing period of their flock by bringing the entirety of their does into heat around a similar time so that they will kid simultaneously, which will reduce the time required for intensive care of the herd (Bhattarai et al., 2020). For synchronization of the estrous cycle, several different hormones (Progesterone, prostaglandins, and their analogues) are used in sequence to control corpus luteum function, stimulate follicular development, and direct ovulation (Omontese, 2018). Thus, it would be more beneficial when AI is performed after estrus synchronization of the does.

3.3 Quality of semen for AI in Nepal

The success of AI was discovered to depend largely on the quality of cryopreserved semen, an imperative tool for the successful execution of a breeding program to set up the pure line breed of goat, which in turn determined the conception rate (Bastola et al., 2018). The quality of semen is a crucial factor that determined the overall process of AI. Thus, should be collected from the appropriate buck and should meet all the necessary criteria. According to a study, the modern process and tests right now being embraced in Nepal for creation and evaluation of the quality of fresh, pre-freeze and frozen semen incorporate assessment for quality at different phases by determining: motility, viability of the cells at the initial, pre-freeze, and post-thawing stages, bacterial contamination, hypo-osmotic sperm swelling tests for cell membrane integrity, and assessment of acrosomal integrity by various staining techniques (Paudel et al., 2007).

3.4 Collection of semen

National Livestock Breeding Office (NLB0) has been creating frozen semen in its laboratory. The facilities for the collection of semen, its handling, protection and storage are accessible at Animal Breeding Division, Nepal Agricultural Research Council (NARC), Khumaltar, and National Livestock Breeding Center, Pokhara, under Department for Livestock Services (Paudel et al., 2007). Production of sperm differs from the breed and the season. The simplest and most exact indirect estimate of testis size and testicular sperm content can be calculated from scrotal circumference (Lueboeuf et al., 2000). There are various methods to collect semen from the desired buck with all the quality traits. The artificial vaginal (AV) method was found to have been practiced in Nepal. To aid the buck's semen collection, a doe indicating proof of estrus i.e., teaser doe is placed near so the contributor buck gets stimulated and can mount her. A group researchers suggested that all the components of AV used for semen collection including the outer rubber cylinder, inner rubber line, rubber band, cone, and collecting tube should be sterilized before collection of semen using an autoclave machine (Bastola et al., 2018). At the National livestock breeding center of Nepal, the tube with collected semen is first labeled with the identification of the breed, eventually, the mouth is sealed with aluminum foil and then kept in a water bath at 37 degrees celsius for five minutes (Bastola et al., 2018). Besides these, large amount of semen was also found to have been exported in Nepal from other countries to meet the demand for goat (Paudel et al., 2007). Eight boer breeds are maintained in the shed for semen production until the end of the fiscal year 2018/19 (NLBO, 2020).

Table 2: Detail of semen imported to NLBO

S.N.	Date	Country	Breed	Semen dose	Source
1	2015	USA	Boer	3000	KUBK
2	2017	USA	Boer	1500	KUBK
			Total	4500	

(Source: NLBO, 2020)

Table 3: Table showing frozen semen (dose) production of Buck (Boer) from 2008/09 to 2018/19 in Nepal.

S.N.	Date	Frozen semen production
1	2008/09	0
2	2009/10	0
3	2010/11	0
4	2011/12	0
5	2012/13	0
6	2013/14	0
7	2014/15	0
8	2015/16	0
9	2016/17	0
10	2017/18	8280
11	2018/19	11689
	Total	19969

(Source: NLBO, 2020)

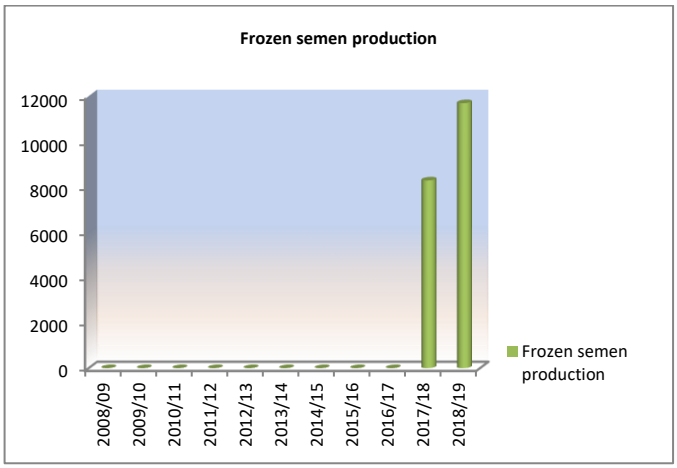

Figure 2: The number of frozen semen (goat) produced from year 2008/09 to 2018/19 in Nepal. (Source: NLBO, 2020)

Figure 2 elaborated that the production of frozen semen for AI in goats is new to Nepal. Previously, semen was not produced within the country. Only after 2017/18, NLBO has started producing goat semen.

3.5 The general method of processing, preservation, and storage of semen in Nepal

The gathered semen must be taken care of cautiously to evade heat shock, cold shock, contamination with water, disinfectants, sunlight, and air, as well as other processes or factors that may diminish sperm viability (Faigl et al., 2012). After collecting semen, it is diluted with normal saline in a cuvette and mixed well with micropipette at National livestock breeding. Then the cuvette is inserted in a sample container of a photometer which is pre-set with the buck semen (Bastola et al., 2018). As, an explicit issue in the protection of goat semen has been found to have the detrimental impact of seminal plasma on the viability of the spermatozoa in diluents containing egg yolk or in milk-based media (Leuboeuf et al., 2000). Andromed R , a soybean lecithin-based extender, has been proposed as a substitution of egg yolk as animal source diluents (Bastola et al., 2018).

Minitube automated filling sealing and printing machine is used for filling sealing and printing of buck semen on the straw, only filled and sealed straw are used for the cooling and those half-filled and unsealed straw are discarded (Bastola et al., 2018). After dilution, the diluted semen is cooled slowly but progressively from collection temperature to storage temperature. The purpose of the temperature decrease is to retard the basal metabolism and to prolong the lifespan of spermatozoa from ejaculation to AI (Faigl et al., 2012). The Styrofoam container is filled with liquid nitrogen, where the rack carrying semen straws is suspended for 10 min above liquid nitrogen, keeping a gap of 5 cm between the surface of liquid nitrogen and the semen straws, and submerged into liquid nitrogen (Bastola et al., 2018). Then the semen straws from each buck are grouped and loaded into a liquid nitrogen canister and stored in at -196°C for approximately 3 months (Bastola et al., 2018).

3.6 AI techniques in goat

Thawing must be carried out before inserting semen into a doe. For fertility to be ideal, semen must be placed in the right place (the uterine end of the cervix or just inside the uterus) in the reproductive tract of the female and at the right time by methods like intracervical, intrauterine, or laparoscopic insemination (Omontese, 2018). A study reported that in any case, using frozen semen, at present intrauterine insemination is the only procedure by which high pregnancy rates can be obtained (Faigl et al., 2012). In does, semen might be placed in the vagina yet the best area to improve fertility is when semen is deposited in the inner cervix (Omontese, 2018). The standard process of inseminating does involve lifting of their rear quarters with their front legs staying on the ground and with the help of a duckbill speculum and penlight locating the cervix, and passing an insemination pipette through the cervix to deposit the semen in the uterine body (Holtz, 2005). According to NLBO (2020) gun loaded with thawed semen is inserted at approximately 30-degree angle till the gun reaches the fornix vagina by holding the shoulder of the gun between the ring and middle fingers and the gun piston is pushed with the thumb slowly (5 seconds) to deposit the semen just outside the internal os to allow semen to drain into the body of the uterus.

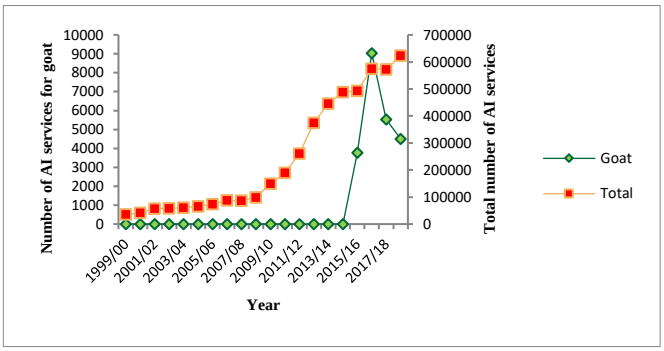

Figure 3: The number of AI services for goat and the total number of AI services in Nepal from 1999/00 to 2018/19. (Source: NLBO, 2020)

Figure 3 depicted that AI services for goats in Nepal commenced from the year 2015/16 by the use of imported frozen semen but AI services for other livestock started earlier from 1990/00. This indicates that AI services for goats in Nepal is new and is yet to be developed. AI services for the goat was found to be highest in the fiscal year 2016/17 but declined afterward. Of the total number of AI in goats in fiscal year 2018/19 in NLBO, 1932 were carried in Pokhara, 1259 in Lahan, and 1308 in Nepaljung. The conception rate was just 35% with 1574.65 conceived animal. The AI coverage% was found less than 1.

Table 4: Status of AI in goats in Nepal

S.N.	NLBOs	Number of AI in goats in fiscal year 2018/19			
1	NLBO, Pokhara	1932			
2	NLBO, Lahan	1259			
3	NLBO, Nepaljung	1308			
Total AI in fiscal year 2018/19		4499	Conception Rate (%)	Total Animal Conceived	AI Coverage(%)
			35	1574.65	<1

(Source: NLBO, 2020)

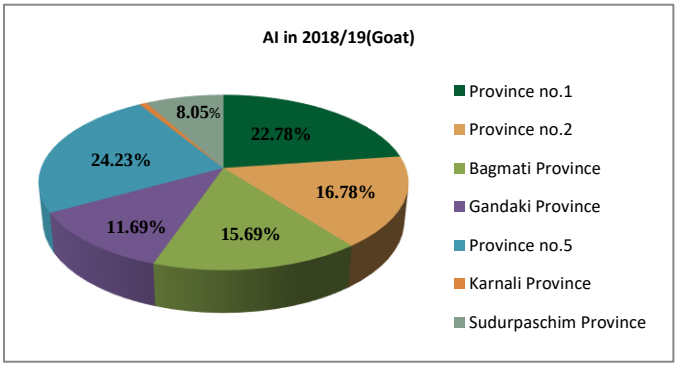

Figure 4: Share of the different provinces in total AI carried in goats in 2018/19. (Source: NLBO, 2020)

Figure 4 shows the share of the different provinces in total AI carried in goats in 2018/19. Among the seven provinces of Nepal, Province no.5 contributed the highest with 24.23% and Karnali Province shared the lowest value of 0.78%. This shows that services for AI are yet to develop in the Karnali Province.

3.7 Factors affecting the conception rate of artificially inseminated bucks

Conception rate is influenced by several factors. Of the various factors, semen quality and female reproductive health play an important role. According to AITC (2020), the following are the criteria for frozen semen to be used in the process:

- Capacity of straw/ dose: 0.25 ml
- Sperm count/ dose: 20 million per dose
- Sperm motility: At least 45%
- Abnormal sperm: Less than 20%

Besides these, the inseminator's skill, semen storage and handling, estrus and heat detection, thawing, time of insemination, and place of deposit also affect conception rates in different ways (AITC, 2020).

3.8 Prospects

Nepal has colossal possibilities in the goat sector. Among Nepal's natural gifts are the diversity of climate and varied topography making it suitable for, among many others, goat production. Artificial Insemination (AI) of semen of high yielding exotic breeds is probably the most ideal alternative to improve goats' genetic characteristics and productivity. It is seen that there have been some attempts in developing AI in goats by establishing facilities for semen collection, processing, preservation, and storage at Animal Breeding Division, Nepal Agricultural Research Council (NARC), Khumaltar, and National Livestock Breeding Center, Pokhara, under Department for Livestock Services. This area is with ample opportunities for improving farm species and their products in Nepal. The development of breeding buck service in Nepal has helped small-holding farmers and will continue to help in the future as well. AI in goats is new to Nepal as compared to other livestock and further work on DNA and molecular level are sure to be done in the future. By using AI in a large-scale, we would be able to fulfill the nation's demand, improve reproductive as well as genetic traits of goats, and at the same time contribute to global food security.

4. Conclusion

Being a developing country based in agriculture, the goat sector is an important part of Nepalese agriculture as well as livelihood. It not only provides manure to increase the productivity of the field but also provides food, milk, and skin, ultimately contributing to global food security. Reproductive biotechnologies like AI have been adopted in Nepal to improve the overall efficiency of goat production systems and it had continued to be an essential reproductive technique for genetic creation and conservation of genetic resources. The adoption of technology on artificial insemination has contributed to the production of crossbred and maintenance of exotic blood levels in the goats of Nepal. However, the result of AI and conception obtained to date is not so convincing. This could be because of a lack of skilled manpower, poor farmers, lack of technologies, and recent development of AI in goats in Nepal. Though semen collection, processing, preservation, and storage facilities are available here, still, they are not in a large amount. More study at the DNA and molecular level for creating advanced technologies for upgrading productivity through breeding, and conservation and utilization of native goat species for their specific genetic potential have to be exploited for harnessing the benefits of farmers of Nepal.

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