http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 7 (11): 1903-1907, 2004
ISSN 1028-8880

Genetic and Non-genetic Factors Affecting the Semen Quality of Bulls

L. Asad, S.S. Husain, M.G.M. Rahman, M.A.M.Y. Khandoker, M.E. Hossain and M.Z. Rahman
Department of Animal Breeding and Genetics, Bangladesh Agricultural University,
Mymensingh-2202, Bangladesh

Abstract: In the present experiment volume, concentration, mass movement and forward movement of semen of different genotypes of bulls relating to body weight, age, sexual maturity and season were evaluated. A total of 1422 semen samples from 22 different bulls of seven genotypes were included in this study from Central Cattle Breeding Station (CCBS), Shavar, Dhaka, Bangladesh. Among the seven genotypes of bulls, only the Friesian bulls gave the largest volume of semen (14.26±0.19 mL), mass movement (4.87±0.07 grade) and forward movement (61.29±0.31%) of sperm. While considering the age, the bulls of 4 to 6 years old provided the highest semen volume (13.60±0.18 mL), sperm concentration (1219.89±10.72 million sperm mL^{-1}), mass movement (4.66±0.06 grade) and forward movement (61.34±0.28%) of sperm. The highest volume (12.01±0.22 mL) of semen, sperm concentration (1182.29±14.30 million sperm mL^{-1}), mass movement (4.40±0.08 grade) and forward movement (58.74±0.54%) of sperm was found in 3 years age of sexual maturity. In case of body weight, the maximum volume of semen (12.16±0.22 mL) and forward movement (60.25±0.45%) of sperm was obtained in the bulls of 400 to 600 kg body weight and the volume was maximize (12.15±0.23 mL) in summer season. The findings suggested that Friesian produced better quality semen than other genotypes while 4 to 6 years age and >600 to 700 kg body weight of bulls performed better than other age and body weight groups. The summer season gave better quality semen than other seasons.

Key words: Genetic, non-genetic, bull, semen

INTRODUCTION

The quality of semen in relation to fertility is determined largely by the motility (%) of sperm. The motility again depends on concentration of spermatozoa, production of live and morphologically normal individual sperm[1] and might be varied on genotype[2]. Naturally, young animals and those of smaller size produce smaller volume of semen. Frequent ejaculation not only results in lower average volume but also affects the quality of semen and when two ejaculates are obtained consecutively, the second usually has the lower volume and quality. The small volume is not harmful, but if accompanied by the low sperm concentration, there have possibility to lower conception rate. It has been noticed that the total sperm concentration per ejaculation was increased with the age of the bull up to 7.5 years and then decreased[3]. Similarly sperm concentration and percentage of motile sperm decreased with the age but the volume of semen is increased[4]. The volume of semen production also affected by season as June and July were reported the best months for semen production while February and March were found the dull season for semen production[5]. It was postulated that in spite of these non-genetic factors, genetic factor (genotype) of the bulls may have effect on semen production and quality. So, the purpose of this study was to examine;

1. The effects of different genotypes (genetic factors) of bulls on semen quality such as volume, concentration and motility.
2. The effect of season and age (non-genetic factors) on semen quality of bulls.

MATERIALS AND METHODS

Animals and data used: Data were collected from the records kept in Artificial Insemination Laboratory, in the Central Cattle Breeding Station (CCBS), Shavar, Dhaka. The experimental animals were divided into seven groups according to their genetic composition and the number of animals in each genotypes and the number of total ejaculates are shown in Table 1.

Feeding and management of bulls: The bulls were fed a balanced ration consisting of 50% mixed concentrated and

Corresponding Author: Dr. M.A.M. Yahia Khandoker, Associate Professor, Department of Animal Breeding and Genetics, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
Tel: +880 91 55695-7 Ext: 2270 Fax: +880 91 55810 E-mail: yahiakh@royalten.net

Table 1: Number of animals and total number of ejaculates of different genotypes of bulls

Genotypes	Female	Male	No. of animals	No. of ejaculates
Pure Friesian (F)	F	F	4	390
Pure Sahiwal (SL)	SL	SL	3	212
Local×Holstein×Friesian×Friesian (L×H×F×F)	L×H×F	F	3	168
Sahiwal×Friesian×Friesian (SL×F×F)	SL×F	F	3	113
Local×Friesian×Friesian (L×F×F)	L×F	F	3	166
Sahiwal×Friesian (SL×F)	SL	F	3	176
Local×F_2 Friesian [L×F(F_2)]	L×F	L×F	3	167
Total			22	1422

50% hay with supplementation of vitamins and minerals. Feeds were given on the basis of TDN (total digestible nutrient) and CP (crude protein). Bulls were tested for fertility before putting them in the breeding herd. Semen was collected using a standard artificial vagina from the bulls thrice a week (Sunday, Tuesday and Thursday). Immediately after collection, semen was kept in warm water at about 100 to 150^{0}F. A total of 1422 ejaculates, (390 from Friesian, Sahiwal×Sahiwal, 167 Local×Holstein×Friesian×Friesian, 118 from Sahiwal×Friesian×Friesian, 165 from Local×Friesian×Friesian, 175 from Sahiwal×Friesian, 196 from Local×F_2 Friesian) was taken to study the quality of semen.

Semen characteristic analyzed: The following records on semen quality were analyzed:

Volume of ejaculate: Volume per ejaculate was recorded immediately after collection from the graduated collection vials.

Concentration: The total number of spermatozoa 3 mL^{-1} of raw semen was enumerated by haemocytometer method. The following formula was used for calculating the total number of spermatozoa/mL of fresh semen.

$$N = \frac{C \times 4000}{S} \times D$$

Where:

N = Number spermatozoa per mL of semen
C = Number of spermatozoa counted in given number of small squares
S = Number of small squares counted
D = Dilution ratio

Motility (Mass movement and forward movement %): Percentage of motility (mass movement and forward movement of spermatozoa) was estimated by microscopic examination and was recorded in intervals of 10%.

Semen volume, sperm concentration and motility (undiluted semen under phase contrast microscope) were recorded for every ejaculate.

Factors included in the analysis: The data on the above parameters were analyzed to see the effect of genotypes of bull, age groups of bulls, body weight groups of bulls, seasons (Summer, Rainy, Winter) and age at sexual maturity (Table 1).

Design of the experiment and statistical analysis: There was sufficient hierarchy in the data structure. The number of observation varied from class to class. So, the statistical design of this experiment was non orthogonal factorial in nature[6]. The Least Square procedure was used to analyze the data for the trait volume per ejaculate, concentration and motility. The statistical analyses were performed using SAS[7] and Harvey[8] computer program.

RESULTS AND DISCUSSION

Effect of different genotypes of bulls on semen quality: The volume of semen, concentration of sperm, mass movement and forward movement of sperm were significantly ($p<0.001$) differ among the genetic groups of bulls. The highest volume of semen was obtained in pure Friesian (14.26±0.19 mL) and the lowest (8.55±0.36 mL) for Sahiwal×Friesian (Table 2). The genetic variation on semen volume is very much practical and supported by other researchers[9,10].

The concentration of semen was also affected by different genetic groups of bulls. The highest concentration of semen was obtained in Local×Friesian×Friesian (1258.43±21.48 million sperm mL^{-1}) and the lowest (921.69±35.52 million sperm mL^{-1}) in Sahiwal×Friesian×Friesian. These results further confirm the genetic variation on semen quality and supported by many researchers[11-13].

The mass movement was also different among the bulls of different genotypes. The highest mass movement of semen was obtained in Friesian breed (4.87±0.07 grade) and lowest (3.37±0.14 grade) for Sahiwal×Friesian×Friesian. Similar studies were made by Hoque[1] who found a mass movement of semen as 3.98±0.04 grade in Local×Friesian, 2.58±0.06 in Friesian and 2.49±0.05 in Sahiwal×Friesian and in the trait of mass movement Local×Friesian crossbred had significant ($p<0.05$) effect as compared to Friesian and Sahiwal×Friesian with same grading system.

Table 2: Mean±S.E of semen quality of different genotypes of bulls

Genotypes	Observation	Volume (mL)	Concentration (million mL^{-1})	Mass movement (grade) (1-5)	Forward movement (%)
F	390	14.26^{a}±0.19	1180.68^{b}±13.06	4.87^{a}±0.07	61.29^{a}±0.31
SL xSL	212	9.45^{d}±0.28	1222.92^{a}±25.34	4.49^{b}±0.12	58.49^{b}±0.95
LxHxFxF	168	13.05^{b}±0.38	1110.71^{c}±18.62	4.32^{b}±0.13	58.87^{ab}±0.87
SLxFxF	113	13.51^{ab}±0.65	921.69^{d}±35.52	3.37^{d}±0.14	55.04^{c}±1.36
LxFxF	166	10.94^{c}±0.30	1258.43^{a}±21.48	4.39^{b}±0.13	59.39^{ab}±0.77
SLxF	176	8.55^{e}±0.36	926.14^{d}±30.98	3.76^{c}±0.14	53.75^{c}±1.32
LxF (F_2)	197	11.46^{c}±0.33	1096.37^{c}±25.04	4.14^{b}±0.13	58.19^{b}±1.01

Means with different superscripts within the same column differ significantly ($p<0.05$), F: Pure friesian, F (F_2): Friesian F_2 generation, H: Holstein, L: Local, SL: Sahiwal

The forward movement was significantly ($p<0.001$) affected by different genotypes of bulls. The highest forward movement of sperm was obtained in Friesian (61.29±0.31%) and the lowest (53.75±1.32%) in Sahiwal×F_2 Friesian. Hoque[1] observed that forward movement of sperm was 54.85±0.90% in Friesian, 58.30±0.53% in local×Friesian and 52.78±0.78% in Sahiwal×Friesian at two years of age.

Effect of age on semen quality: Bulls were divided into three age groups as 4 to 6 years, >6 to 9 years and >9 to 12 years. The volume of semen, concentration of sperm, mass movement and forward movement of sperm were significantly ($p<0.001$) affected by different age groups of bulls. The average volume of semen, concentration of sperm, mass movement and forward movement of sperm of the three age group bulls were 13.60±0.18, 10.71±0.24, 10.67±0.25; 1219.89±10.72, 1064.52±16.07, 1055.14±19.62; 4.66±0.06, 4.30±0.08, 3.94±0.09 and 61.34±0.28, 56.91±0.68, 56.31±0.76. The highest volume of semen was obtained from the bulls of 4 to 6 years of age and the lowest volume was in >9 to 12 years of age. These findings supported by many researchers[2,12-18]. Most of them reported that the highest concentration of sperm in semen was 1219.89±10.72 million mL^{-1} for 4 to 6 years of age and lowest value for 1055.14±19.62 million mL^{-1} for >9 to 12 years of age. Mean concentration decreased with the increase of age (Table 3) which is in agreement with Rodionovskii[19].

Effect of body weight of bulls on semen quality: The bulls were divided into three groups of body weight as 400 to 600 kg, >600 to 700 kg and >700 to 900 kg (Table 3). Significantly ($p<0.01$) the highest and lowest volume of semen were found 12.16±0.22 and 11.85±0.24 from the bulls of 400 to 600 kg body weight and from the bulls of >600 to 700 kg body weight respectively while the highest concentration was 1158.19±16.39 million sperm mL^{-1} for >700 to 900 kg body weight and lowest value was 1.74.64±15.82 million sperm mL^{-1} for >600 to 700 kg body weight. Similarly mass movement was found highest (4.46±0.08) in >600 to 700 kg body weight and the highest forward movement (60.25±0.45) was observed in 400 to 600 kg body weight bulls. Hoque and Cooper[20] reported that relationship of final weight with semen characteristics scores were low with a slight tendency for the heavier bulls to receive better scores for appearance, density and rating of semen. Musgrave[21] and Dunn[22] studied the growth as a factor in the initiation of spermatogenesis, testicular weight is significantly correlated with body weight in young bulls Van demark[23]. They found a correlation of 0.3 between testis weight and the total number of sperm produced per ejaculation.

Effect of different season on semen quality: The highest volume of semen (12.15±0.23 mL) was obtained during summer while lowest amount (11.67±0.21 mL) was in rainy season (Table 4). These findings also supported the results of Taylor *et al.*[24]. They found the highest percentage of ejaculates with the largest semen volume during summer months.

The average concentration was 1085.66±17.09 million sperm mL^{-1} for winter, 1126.61±14.62 million sperm mL^{-1} for summer and 1149.82±14.88 million sperm mL^{-1} for rainy season. The concentration of 1149.82±14.88 million sperm mL^{-1} for rainy season and 1126.62±14.62 million sperm mL^{-1} in summer both were jointly higher than it was in winter (1085.66±17.09 million sperm mL^{-1}) (Table 4). This result also supports the statement of Hardin *et al.*[25]. They reported that concentration of semen was significantly ($p<0.01$) higher during summer and autumn than in wither and spring in Angus bulls.

Incase of mass movement of sperm both 4.04±0.07 and 4.56±0.09 value obtained in rainy and winter season, respectively were jointly lower than it was in summer (4.49±0.08). Forward movement in rainy season (59.28±0.52%) and in summer (59.16±0.54%) were jointly higher than it was in winter season (56.68±0.66%). Saxena and Tripathi[26] observed that there were no significant differences between seasons in respect of percent sperm motility and live cells at any storage period. Sperm motility was maintained satisfactorily during winter, spring, rainy and summer seasons upto 48 h. Winter, spring and autumn had lower values compared to summer and rainy season, which supports the current findings.

Table 3: Mean±S.E of semen quality of different age and body weight groups of bulls

	Non-genetic factors					
	Age groups (year)			Body weight groups (kg)		
Semen characteristics	4-6	>6-9	>9-12	400-600	>600-700	>700-900
Volume (mL)	13.60^{a}±0.18 (570)	10.71^{b}±0.24 (431)	10.67^{c}±0.25 (421)	12.16^{c}±0.22 (445)	11.35^{b}±0.24 (483)	12.09^{a}±0.23 (494)
Concentration (million mL^{-1})	1219.89^{a}±10.72 (570)	1064.52^{b}±16.07 (431)	1055.14^{c}±19.62 (421)	1139.69^{a}±13.57 (445)	1074.64^{b}±15.82 (483)	1158.19^{a}±16.39 (494)
Mass movement (grade)	4.66^{a}±0.06 (570)	4.30^{b}±0.08 (431)	3.94^{c}±0.09 (421)	4.26^{b}±0.08 (445)	4.46^{b}±0.08 (483)	4.27^{a}±0.08 (494)
Forward movement (%)	61.34^{a}±0.28 (570)	56.91^{b}±0.68 (431)	56.31^{c}±0.76 (421)	60.25^{a}±0.45 (445)	56.63^{b}±0.66 (483)	58.79^{a}±0.55 (494)

Table 4: Mean±S.E of semen quality of bulls at different seasons and at sexual maturity

	Non-genetic factors				
	Seasons			Sexual maturity (Year)	
Semen characteristics	Winter	Summer	Rainy	2	3
Volume (mL)	11.78^{a}±0.27 (401)	12.15^{a}±0.23 (472)	11.67^{a}±0.21 (549)	11.76^{a}±0.17 (880)	12.01^{b}±0.22
Concentration (million mL^{-1})	1085.66^{b}±17.09 (401)	1126.61^{a}±14.62 (472)	1149.82^{a}±14.88 (549)	1088.14^{b}±11.31 (880)	4.40^{a}±0.08 (542)
Mass movement (grade)	4.56^{a}±0.09 (401)	4.49^{a}±0.08 (472)	4.04^{b}±0.07 (549)	4.29^{b}±0.06 (880)	4.40^{a}±0.08 (542)
Forward movement (%)	56.68^{b}±0.66 (401)	59.16^{a}±0.54 (472)	59.28^{a}±0.52 (549)	58.37^{a}±0.41 (880)	58.74^{a}±0.54 (542)

Means with different superscripts within the same column differ among themselves. Figure in the parenthesis indicates the no. of observation

Effect of different age of sexual maturity of bulls: The average semen volume, concentration of sperm, mass movement and forward movement for 2 years of age and 3 years of age bulls were 11.76±0.17, 12.01±0.22; 1088.14±11.31, 1182.29±14.30; 4.29±0.06, 4.40±0.08 and 58.37±0.41, 58.74±0.54, respectively (Table 4). The volume, mass movement and forward movement of sperm were non-significantly affected by different age of sexual maturity. But significantly ($p>0.01$) highest semen volume and concentration of sperm was found in bulls of 3 years of age. These results also support the statement of Tomar *et al.*[27]. They stated that ejaculate volume, mass motility and live percentage of spermatozoa are increased with growing age of the bulls while the live abnormal percentage of spermatozoa is decreased simultaneously.

These results indicated that Friesian produce better quality semen than other genotypes while 4 to 6 years age of bulls gave better quality semen than other age groups and that 600 to 700 kg body weight of bulls produced better quality semen than other body weight groups of bulls. The summer season gave better quality semen than other seasons.

ACKNOWLEDGMENTS

We wish to express our sincere thanks to Mr. Abdur Razzaq, former Director General DLS, for providing the facilities to conduct this research. We are also grateful to Mr. Aynul Hoque, Assistant Director and all other employees of the Artificial Insemination Division, Central Cattle Breeding Station Savar, Dhaka for their assistantship during this studies.

REFERENCES

1. Hoque, M.D., 1998. Phenotypic variation and repeatability of semen characteristics of purebred and crossbred bulls. M.Sc. Thesis, Bangladesh Agricultural University, Mymensingh.
2. Stalhammar, E.H., L. Janson and J. Philipsson, 1988. Genetic and environmental studies on semen characteristics as fertility in young A.I. bulls. Proceedings, VI World Conference on Animal Production, pp: 576.
3. Amann, R.P., 1982. Bull management to maximum semen output. 6th NAAB Tech. Conf., February 20-21, pp: 1-6.
4. Moussa, A.M., 1997. Semen quality of bulls in relation to age and origin. J. Dairy Sci., 36: 576.
5. Everett, R.W. and B. Bean, 1982. Environmental influences on semen output. J. Dairy Sci., 65: 1303-1310.
6. Snedecor, G.W. and W.G. Cochran, 1980. Statistical Methods (7th Edn.). The Lowa State University Press. Lowa, USA.

7. SAS., 1990. Statistical Analysis System. Version 603. SAS Institute, Carry NC. , pp: 25-109.
8. Harvey, W.R., 1990. Mixed model least-squares and maximum likelihood computer programme. PC-2 version. Mimeograph, Ohio State University, Ohio, USA.
9. Hafez, E.S.E., 1974. Reproduction in Farm Animals. 3rd Edn., Chapter 6, pp: 409.
10. Raju, M.S. and A.R. Rao, 1982. Note on the semen characteristics of crossbred and purebred bulls. Indian J. Ani. Sci., 51: 1230-1232.
11. Orlovskil, I.A., 1972. Inheritance of semen production in bulls. Stornik-Nauchnykh-Trudov-Belorusskoi-Sel' Sko-khozyaistve-nnoi-Akademii, 92: 117-133.
12. Rao, N.T.L. and R.A. Rao, 1978. Semen characteristics of crossbred bulls. Indian Vet. J., 55: 692-700.
13. Hafez, E.S.E., 1993. Reproduction in Farm Animals. 6th Ed. Chapter 5. Lea and Febiger, Philadelphia.
14. Hazarika, M., V.B. Saxana and S.S. Tripothi, 1988. Crossbred bull seminal characters and genetic constitution. Indian J. Ani. Sci., 58: 887-1006.
15. Ivanenkovs, I.A., A.G. Shulimov and V.M. Sopelnik, 1979. Changes with age in the quantity and quality of bull semen. Zhivotnovstvo, 6: 71-72.
16. Jamriska, M. and J. Novy, 1980. Repeatability of conception rate to 1st insemination with semen of slovakian pied bulls. Vysoka Skoly Pol 'Nohospodarska' Nitra, Czechslovakia, Acta Zootechnica, Nitra, 36: 49-68.
17. Ziegler, M., 1984. Relationship between semen and fertility characters of A. I. bulls at the Meggle A.I. Centre, Reitmehring Ropttmoos, pp: 212.
18. Eckardt, H., H. Franz and E. Oschika, 1973. Semen testing and selection of young dairy bulls. Forschungszentrum fur Tierproduletion, Dummerstort Rostock, German Democratic Republic, Tierzucht, 27: 533-535.
19. Rodionovskii, V.M., 1977. Age variation and heritability of semen production induces in kostroma stud bulls. Trudy-vseso-yuznyi-sel Skokhozyoistvennyi-Institut-Zaochnogo-obrazovaniya, 40: 61-75.
20. Hoque, M. and R.J. Cooper, 1968. Relationship between growth rate and semen characteristics in young bulls. Ani. Sci. J. Pak., 1: 58-61.
21. Musgrave, S.D., 1951. The influence of three levels of nutrients intake on the growth and sexual development of young Holstein bulls. Ph.D. Thesis, Cornell Univ. Ithaca, New York.
22. Dunn, H.O., 1952. Further studies of influence of three levels of nutrient intake on the gowth and sexual development of young Holstein bulls. Ph.D. Thesis, Cornell Univ. Ithaca, New York.
23. Van demark, N.L., 1956. Quantitative aspects of semen production in bulls. II. Intl. Cog. An. Repr. Plenary Papers: 80.
24. Taylor, J.F., B. Bean, C.E. Marshall and J.J. Sullivan, 1985. Genetic and environmental components of semen production traits of artificial insemination of Holstein bulls. J. Dairy Sci., 68: 2703-2722.
25. Hardin, D.R., D.J. Chenoweth, T.H. Friend and R.D. Randel, 1982. Seasonal variation in seminal parameters and libido of Angus and Brahman bulls. Ani. Breed. Abst., 51: 679.
26. Saxena, V.B. and S.S. Tripathi, 1986. Seasonal variation in semen characteristics and preservability in Red Dane Bulls. Indian Vet. J., 63: 76-77.
27. Tomar, N.S., K.C. Sharma and S.N. Shukla, 1985. Semen production in relation to the age of Holstein-Friesian X Harina bulls. Indian Vet. J., 62: 499-501.