Associations between sperm abnormalities, breed, age, and scrotal circumference in beef bulls

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Abstract

The objectives of this study were to determine the associations of breed, age, and scrotal circumference (SC), and their interaction, on the prevalence of sperm abnormalities in beef bulls in Alberta, Canada, and the percentage of satisfactory potential breeders identified during breeding soundness examination solely due to normal sperm morphology. Eosin-nigrosin stained semen smears and evaluation reports of 1642 bull breeding soundness evaluations were procured from 6 veterinary clinics in Alberta. Sperm morphology was determined for at least 100 sperm per bull. The most common defects were detached head [4.86% ± 5.71%; mean ± standard deviation *(s)*], distal midpiece reflex (6.19% ± 9.13%), and bent tail (1.01% ± 1.54%). Although breed, age, and SC did not significantly affect the prevalence of head or midpiece defects, morphologically normal or abnormal sperm, tail defects were more prevalent in Angus and Hereford bulls compared with other breeds. Overall, solely on the basis of sperm morphology, 1363 (83.0%) bulls were classified as satisfactory potential breeders and the remainder 279 (17.0%) as unsatisfactory (> 30% abnormal sperm, > 20% defective heads, or both). Although not significantly different, the breed with the highest percentage of satisfactory potential breeders was Limousin (90.6%) and the lowest was Hereford (78.8%). That 17% of bulls subjected to breeding soundness evaluation were designated as unsatisfactory solely on the basis of sperm morphology highlights its importance.

Résumé

Les objectifs de la présente étude étaient de déterminer les associations de race, âge et circonférence scrotale (SC), et leur interaction sur la prévalence d'anomalies spermatiques chez les taureaux de l'Alberta, Canada, et le pourcentage de reproducteurs potentiels satisfaisants identifiés lors de l'examen de la qualité reproductrice basé uniquement sur la morphologie normale du sperme. Des frottis de semence soumis à une coloration à l'éosine-négrosine de même que les rapports d'évaluation de la qualité reproductrice de 1642 taureaux ont été obtenus de 6 cliniques vétérinaires de l'Alberta. La morphologie spermatique a été déterminée pour au moins 100 spermatozoïdes par taureau. Les défauts les plus fréquents étaient des têtes détachées [4,86 % ± 5,71 %; moyenne ± écart-type (s)*], le repli de la pièce moyenne (6,19 % ± 9,13 %) et des queues recourbées (1,01 % ± 1,54 %). Bien que la race, l'âge et la SC n'affectaient pas de manière significative la prévalence de défauts de la tête ou de la pièce médiane, le sperme morphologiquement normal ou anormal, les anomalies de la queue avaient une prévalence plus élevée chez les taureaux des races Angus et Hereford comparativement aux autres races. Globalement, en se basant uniquement sur la morphologie des spermatozoïdes, 1363 taureaux (83,0 %) étaient classés comme des reproducteurs potentiels satisfaisants alors que les 279 autres (17,0 %) étaient insatisfaisants (> 30 % de spermatozoïdes anormaux, > 20 % de têtes avec des défauts, ou les deux). Bien que la différence n'était pas significative, la race Limousin (90,6 %) avait le pourcentage le plus élevé de reproducteurs potentiels satisfaisants tandis que la race Hereford avait le pourcentage le plus faible (78,8 %). Le fait que 17 % des taureaux soumis à une évaluation de la qualité reproductrice ont été désignés comme insatisfaisant basé uniquement sur la morphologie du sperme démontre l'importance de cet examen.*

(Traduit par Docteur Serge Messier)

Introduction

Bull breeding soundness evaluation (BBSE) is an economically important component of beef herd management (1,2). Protocols for BBSE developed by the American Society of Theriogenology (3) and the Western Canadian Association of Bovine Practitioners (4) are widely used by North American veterinarians for routine evaluation of breeding bulls (5,6). In these protocols, physical soundness, the integrity of the reproductive tract, and semen evaluation are assessed and the bull classified as a satisfactory, questionable, or unsatisfactory potential breeder. Among the traits assessed during a breeding soundness evaluation, scrotal circumference (SC) and semen quality endpoints (such as motility and morphology) are highly correlated with fertility (7).

The importance of sperm morphology in BBSE has been well-documented (8). Morphologically abnormal sperm can reduce rates of fertilization and embryonic development (9–11). It has been generally accepted that bull semen classified as satisfactory should contain at least 70% morphologically normal sperm, with no more than 20% of sperm with an abnormal head (8). Since spermatogenesis in bulls requires nearly 61 d, followed by epididymal maturation for approximately 11 d (8), most sperm abnormalities reflect previous

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Table I. Association between sperm abnormalities (mean ± s) and breed in beef bulls

Breed	Number of bulls	Sperm defects Head[c]	Midpiece[d]	Tail[e]	Total Abnormal	Normal
Angus	807	5.37 ± 6.54	13.26 ± 13.89	1.82 ± 2.54[a]	20.45 ± 16.60	75.55 ± 16.00
Simmental	335	5.75 ± 5.52	13.54 ± 14.30	1.35 ± 1.53[b]	20.64 ± 16.44	79.36 ± 16.44
Charolais	207	5.42 ± 5.99	11.52 ± 10.89	1.17 ± 1.40[b]	18.11 ± 12.61	81.89 ± 12.61
Limousin	117	4.50 ± 4.25[a]	11.39 ± 13.47	1.08 ± 1.38[b]	16.97 ± 14.56	83.03 ± 14.56
Gelbvieh	91	6.53 ± 7.14[b]	9.92 ± 7.34	1.09 ± 1.98[b]	17.54 ± 10.67	82.46 ± 10.67
Hereford	85	5.55 ± 5.57	13.74 ± 10.73	1.54 ± 2.26[a]	20.84 ± 13.90	79.16 ± 13.90
Overall	1642	5.47 ± 6.13	12.80 ± 13.19	1.53 ± 2.14	19.80 ± 15.59	80.20 ± 15.71

s — standard deviation.

[a,b] Within a column, means without a common superscript differed ($P < 0.01$).

[c] Primarily detached head, defects in size and shape, nuclear vacuoles, and acrosomal defects.

[d] Primarily distal midpiece reflex, bowed midpiece, proximal droplet.

[e] Primarily coiled or bent tail.

disturbances (8,12). In that regard, sperm morphology largely reflects the health status of the seminiferous tubules and to a lesser extent, the epididymides.

Sperm abnormalities have traditionally been classified by location of the defect (head, midpiece, tail), or its site of origin (primary: testis; secondary: epididymis; tertiary: accessory glands/post-ejaculation). Blom (13) classified sperm abnormalities according to their effect on fertility: major defects include most abnormalities of the head and midpiece, proximal cytoplasmic droplets and single abnormalities present in a high percentage, whereas minor defects include looped tails, detached sperm heads, and distal cytoplasmic droplets. More recently, based on breeding trials, analysis of non-return rates to artificial insemination (AI), and in vitro fertilization (IVF) studies, the notion of compensable and uncompensable abnormalities has been developed (14,15). As the sperm head contains the genetic material and key effectors of fertilization, most abnormalities of head are associated with a significant impairment of fertility (16,17). Abnormal condensation of chromatin (18) and abnormal nuclear shape (19,20) are closely associated with reduced fertility. The misshapen pyriform head abnormality impairs both fertilization rate and subsequent embryonic development (21), with failure of cleavage being the primary outcome. Acrosomal defects are also associated with reduced fertility. Thundathil et al (22) used sperm with knobbed acrosome defects for IVF and found that no sperm with the defect penetrated the zona pellucida, and that the embryos that were fertilized by normal sperm from affected bulls had a reduced cleavage rate compared with normal control bulls. Abnormalities of the midpiece and tail generally arise as defects of spermatogenesis and sperm with such abnormalities are either non-motile or have abnormal motility (8). Consequently, the presence of such abnormalities is generally associated with subfertility (13). The distal midpiece reflex abnormality, a defect which develops in the epididymis, resembles a looped tail with a droplet enclosed within the loop. A proximal cytoplasmic droplet is considered a defect of spermatogenesis (18) and a high percentage of sperm affected with proximal cytoplasmic droplets results in impaired fertility. The proportion of sperm with proximal droplets is related to non-return rate to AI and to pregnancy rate in superovulated heifers (17,23). Furthermore, when sperm with proximal droplets have been used in IVF, cleavage rates of embryos are poor (9,24).

A significant increase in the percentage of sperm with normal acrosome and tail morphology has been reported in Estonian Holstein bulls as the age advanced from 3 to 7 y (25). Scrotal circumference, the most easily obtainable measure of a bull's ability to produce adequate numbers of spermatozoa, is highly correlated with testicular volume and semen quality (26,27). It had a negative linear regression with the incidence of primary sperm defects (28).

The prevalence and importance of factors affecting semen quality and breeding soundness classification in beef bulls (6), and the proportion of beef bulls in western Canada with a mature spermiogram at 11 to 15 mo of age (29), are known. However, there is a paucity of information regarding the association of breed, age, and scrotal circumference on the prevalence of sperm defects in beef bulls. Therefore, the objectives of the present study were to determine the associations between sperm abnormalities and breed, age, SC, and the percentage of satisfactory potential breeders, based on sperm morphology, among beef bulls in Alberta.

Materials and methods

Six veterinary clinics actively involved in BBSE were identified to represent the entire province. A total of 1642 reports of BBSE conducted during 2009 and the corresponding eosin-nigrosin stained semen smears, were procured as convenience samples for the study. Information on breed, age, and SC were retrieved from these BBSE reports. Our study involved beef bulls representing 6 breeds common in Alberta. Bull distribution by breed was Angus (n = 807), Simmental (n = 335), Charolais (n = 207), Limousin (n = 117), Gelbvieh (n = 91), and Hereford (n = 85). These data were initially grouped and compared, taking into account the month-wise age of the bulls. As the number of bulls in each month category varied substantially, bulls were subsequently grouped into 4 age groups; 11 to 13 mo (n = 620), 13.5 to 18 mo (n = 150), 19 to 26 mo (n = 621), and > 26 mo (n = 251). The grouping was done based on approximate age at puberty and sexual maturity, as well as to provide a reasonable distribution of data among groups. Sperm morphology was evaluated in the andrology research laboratory of the Faculty of Veterinary Medicine, University of Calgary. For this, eosin-nigrosin stained semen smears obtained from field veterinarians (used for BBSE) were examined by an experienced researcher, using a phase contrast microscope (Leica DM2500; Wetzlar, Germany). In order to avoid variations in morphology assessment between operators, all slides were evaluated by the same person. Moreover, a preliminary comparison of the morphology evaluations by the researcher and the field veterinarians showed 92% agreement and the intra-operator variance (differences in the percentage of sperm abnormalities recorded by the researcher after reading the same slides at 2 occasions) in the sperm morphology examination was < 0.5%.

One hundred spermatozoa were examined per slide from each bull at 1000× magnification and each normal sperm formed a single record. However, as the identification of specific abnormalities was an important consideration, each defect was counted separately, even if multiple defects occurred on the same sperm. Sperm defects were grouped as follows: head defects (detached head, defects in size and shape, nuclear vacuoles, acrosomal defects, and others); mid-piece defects (distal mid-piece reflex, bowed mid-piece, proximal droplet, and others); and tail defects (bent tail, coiled tail, and others).

Summary data on breed, age, SC, and sperm morphological defects were compiled. Two-way analysis of variance was done to determine the effects of breed, age, scrotal circumference, and their interaction, on percentage of normal sperm; percentage of sperm with head, midpiece, and tail defects; and percentage of satisfactory potential breeders. If there was a significant main effect or interaction, Fisher's Least Significant Difference (LSD) test was used to locate differences. Percentage data were converted to a proportion, an arc sine transformation was done, and transformed data were analyzed (non-transformed data were reported). All statistical analyses were done using computer software (SAS, version 9.2; SAS, Cary, North Carolina, USA), and for all analyses, $P < 0.05$ was considered significant.

Results

Association between sperm abnormalities and breed in beef bulls

Association between sperm morphology and breeds are shown (Table I). Although the mean percentage of head defects did not differ significantly among Angus, Simmental, Charolais, and Hereford, it was significantly lower in Limousin and higher in Gelbvieh ($P < 0.01$). The mean percentage of midpiece defects and morphologically normal or abnormal sperm were uniform among breeds. Conversely, the mean percent of tail defects were higher ($P < 0.01$) in Angus and Hereford bulls compared with other breeds. Overall, midpiece defects (12.80% ± 13.19%) were higher ($P < 0.01$) than head (5.47% ± 6.13%) and tail defects (1.53% ± 2.14%). Head defects detected among various breeds included detached heads, defects in size and shape of head, nuclear vacuoles, acrosomal defects and others (such as extra implantation fossa and double head). Midpiece defects included distal midpiece reflex, bowed midpiece, proximal droplets, and others, such as pseudodroplets, Dag-like defect, abaxial attachment of tail, double midpiece, and segmental aplasia. Tail defects included bent tail and coiled tail (Table II).

Table II. Mean ± standard deviation (s) prevalence of specific sperm defects among Alberta beef bulls

	Number		Head defects						Midpiece defects					Tail defects			Total	
Breed	of bulls		DH	DSS	NV	AD	Others	Total	DMR	Bowed	PD	Others	Total	Bent	Coiled	Total	Abnormal	Normal
Angus	807	Mean	4.72	0.41	0.18	0.10	0.00	5.37	6.40	1.47	3.13	2.28	13.26	1.18	0.64	1.82[a]	20.45	75.55
		s	6.04	1.01	1.62	0.52	0.00	6.54	9.69	2.55	7.58	4.75	13.89	1.86	1.78	2.54	16.60	16.00
Simmental	335	Mean	5.12	0.54	0.12	0.06	0.01	5.75	6.46	1.24	3.56	2.30	13.54	0.94	0.41	1.35[b]	20.64	79.36
		s	4.95	1.10	1.87	0.26	0.09	5.52	9.08	2.33	7.86	4.77	14.30	1.16	1.18	1.53	16.40	16.44
Charolais	207	Mean	4.74	0.58	0.02	0.02	0.00	5.42	5.84	1.01	2.31	2.38	11.52	0.86	0.29	1.17[b]	18.11	81.89
		s	5.67	1.51	0.18	0.87	0.00	5.99	7.32	1.94	5.58	4.89	10.89	1.14	0.75	1.40	12.60	12.61
Limousin	117	Mean	3.97	0.55	0.03	0.12	0.01	4.50[a]	6.33	0.89	2.91	1.29	11.39	0.82	0.26	1.08[b]	16.97	83.03
		s	4.02	0.85	0.16	0.49	0.09	4.25	11.16	1.44	7.54	3.56	13.47	1.03	0.75	1.38	14.50	14.56
Gelbvieh	91	Mean	6.23	0.49	0.02	0.05	0.01	6.53[b]	4.05	0.82	3.32	1.76	9.92	0.69	0.40	1.09[b]	17.54	82.46
		s	7.17	0.74	0.15	0.23	0.10	7.14	4.14	1.23	5.15	2.42	7.34	1.00	1.67	1.98	10.60	10.67
Hereford	85	Mean	5.08	0.49	0.01	0.07	0.02	5.55	6.12	1.53	2.85	3.28	13.74	0.68	0.86	1.54[a]	20.84	79.16
		s	5.46	0.93	0.11	0.37	0.15	5.57	8.44	2.65	5.25	4.46	10.73	1.18	2.05	2.26	13.90	13.90
Overall	1642	Mean	4.86	0.48	0.12	0.10	0.01	5.47	6.19	1.29	3.10	2.25	12.80	1.01	0.52	1.53	19.80	80.20
		s	5.71	1.08	1.42	0.52	0.08	6.13	9.13	2.33	7.19	4.59	13.19	1.54	1.54	2.14	15.59	15.71

[a,b] Within a column, means without a common superscript differed ($P < 0.01$).

DH — detached head; DSS — defects in size and shape; NV — nuclear vacuoles; AD — Acrosomal defects; DMR — distal midpiece reflex; PD — proximal droplet.

Table III. Association between sperm abnormalities (mean ± s) and age in beef bulls

Age groups (mo)	Number of bulls	Sperm defects			Total	
		Head	Midpiece	Tail	Abnormal	Normal
11 to 13	620	5.47 ± 5.69	15.02 ± 14.60	1.47 ± 2.02	21.95 ± 16.50	78.05 ± 16.50
13.5 to 18	150	5.83 ± 8.30	15.36 ± 15.68	1.58 ± 1.78	22.77 ± 18.57	77.23 ± 18.57
19 to 26	621	5.30 ± 6.30	10.60 ± 11.26	1.66 ± 2.37	17.56 ± 14.48	82.44 ± 14.48
> 26	251	5.65 ± 5.17	11.25 ± 11.08	1.37 ± 2.03	18.27 ± 12.79	81.73 ± 12.79
Overall	1642	5.47 ± 6.13	12.80 ± 13.19	1.53 ± 2.14	19.80 ± 15.59	80.20 ± 15.71

s — standard deviation.

Table IV. Association between sperm abnormalities (mean ± s) and scrotal circumference (SC) in beef bulls

	Sperm defects			Total	
SC (cm)	Head	Midpiece	Tail	Abnormal	Normal
35.47	5.47	15.02	1.47	21.95	78.05
36.64	5.83	15.36	1.58	22.77	77.23
39.69	5.30	10.60	1.66	17.56	82.44
41.20	5.65	11.25	1.37	18.27	81.73

s — standard deviation.

Association between sperm abnormalities and age in beef bulls

Association between sperm morphology and age of the bulls are shown in Table III. Even though the midpiece defects were slightly higher in young bulls compared with bulls older than 1.5 y, there was no significant association between age and sperm abnormalities.

Association between sperm abnormalities and SC in beef bulls

Association between various sperm abnormalities and SC are shown in Table IV. Although mean SC increased with the age of the bulls, the mean percentage of sperm abnormalities did not differ significantly.

Associations between SC, breed, and age of beef bulls

Mean SC according to age groups is shown (Table V). Limousin bulls had the lowest SC in all age groups, whereas Simmental bulls had the highest SC in the 11 to 13 mo and 19 to 26 mo age groups. Angus and Hereford bulls had the highest SC in 13.5 to 18 mo and > 26 mo age groups, respectively, but none was significantly different (Table V). The overall increase in SC as the age advanced from 11 to 13 mo to above 26 mo was 5.73 cm ($P < 0.01$). It was 7.20, 6.44, 5.86, 5.71, 5.64, and 4.95 cm, respectively, in Hereford, Gelbvieh, Charolais, Angus, Simmental, and Limousin bulls.

Percentage of satisfactory potential breeders classified exclusively based on sperm morphology among beef bulls

Percentage of satisfactory potential breeders based on sperm morphology among various breeds and age groups were summarized (Table VI). Of the 1642 bulls subjected to sperm morphology evaluation, 1363 (83.0%) were classified as satisfactory and the remaining 279 (17.0%) as unsatisfactory potential breeders. The highest percentage of satisfactory potential breeders was from Limousin (90.6%) and the lowest from Hereford bulls (78.8%). Limousin bulls had the highest percentage of satisfactory potential breeders in the age groups 11 to 13 mo, 19 to 26 mo and > 26 mo. However, Gelbvieh was the predominant breed classified as satisfactory in 13.5 to 18-month-old group.

Discussion

The overall prevalence of morphologically abnormal sperm in beef bulls was approximately 20%. Distal midpiece reflex was the most prevalent sperm abnormality, followed by detached head and bent tail. Mean SC in all 6 breeds of bulls increased with age and was lowest in Limousin, regardless of age. Of the 1642 bulls evaluated, 83% were classified as satisfactory potential breeders based on sperm morphology.

Among the 3 major types of sperm defects (head, midpiece, and tail) in Alberta beef bulls, midpiece defects were the most common, followed by head and tail defects. Among the various midpiece defects detected, distal midpiece reflex was most predominant, followed by proximal cytoplasmic droplet defect. This observation was consistent with a previous report that distal midpiece reflex is the most common sperm tail abnormality found in bull semen, regardless of breed (8). Although this defect had little effect upon fertility in AI, it caused subfertility in natural service sires (18,30). Of the head abnormalities encountered, detached head was the most common. In the semen of bulls with acceptable semen quality, it was common to find a small percentage of detached sperm heads. Similarly, an average prevalence of 5.3% detached heads was found in 1001 western Canadian range bulls (8). The common causes for large number of spermatozoa with detached heads in a semen sample are testicular hypoplasia, testicular degeneration, senescence of spermatozoa due to sexual inactivity, and occasionally specific conditions, such as decapitated sperm defect (8).

There was no significant association between the mean percentage of sperm abnormalities, total abnormal and normal sperm, and age and SC of the bulls.

Limousin bulls had the lowest SC, regardless of age. Conversely, Simmental bulls had the highest SC in 11 to 13 mo and 19 to 26 mo

Table V. Mean ± s scrotal circumference (cm) of beef bulls, among various breed and age groups

	Bull age (mo)			
Breed	11 to 13 (n = 619)	13.5 to 18 (n = 150)	19 to 26 (n = 622)	> 26 (n = 251)
Angus	35.44 ± 3.02	36.93 ± 2.04	39.81 ± 2.68	41.15 ± 2.89
Simmental	36.31 ± 1.96	36.47 ± 2.09	40.91 ± 2.55	41.95 ± 2.80
Charolais	35.81 ± 2.27	36.69 ± 2.41	39.58 ± 2.85	41.67 ± 2.82
Limousin	33.18 ± 1.84	33.40 ± 2.68	35.23 ± 2.28	38.13 ± 2.23
Gelbvieh	35.06 ± 2.47	34.00	38.72 ± 2.44	41.50 ± 2.71
Hereford	35.40 ± 2.00	—	39.94 ± 2.53	42.60 ± 2.97
Overall	35.47 ± 2.71^{a}	36.64 ± 2.23^{b}	39.69 ± 2.86^{c}	41.20 ± 2.98^{d}

s — standard deviation.

^{abcd} Within a row, means without a common superscript differed ($P < 0.01$).

Table VI. Percentage of satisfactory potential breeders, classified solely based on sperm morphology, across various breed and age groups

		Age (mo)				
Breed	Number of bulls	11 to 13 (n = 619)	13.5 to 18 (n = 150)	19 to 26 (n = 622)	> 26 (n = 251)	Overall (n = 1642)
Angus	807	82.92	71.05	82.87	83.74	81.91
Simmental	335	68.29	91.18	89.63	90.70	82.09
Charolais	207	85.48	82.35	89.41	80.77	85.99
Limousin	117	85.71	80.00	91.49	100.00	90.60
Gelbvieh	91	75.00	100.00	88.24	93.75	83.52
Hereford	85	66.67	0.00	85.71	85.00	78.82
Overall	1642	79.16	78.67	86.33	86.85	83.01

old animals, whereas Angus and Hereford bulls had the highest SC in 13.5 to 18 mo and > 26 mo age groups. Coulter et al (31) reported that Simmental had the largest SC, followed by Angus, Charolais, Hereford, Shorthorn, and Limousin at 730 d of age, whereas in another report, SC was highest in Simmental and lowest in Limousin at 365 d of age (32). The SC increased as age advanced, regardless of breed, and at above 26 mo of age SC was > 42 cm in Hereford and > 41 cm in Angus, Simmental, Charolais, and Gelbvieh bulls. Conversely, it was > 38 cm in Limousin bulls older than 26 mo of age. The American Society of Theriogenology (3) recommended that all yearling bulls intended for breeding should have a minimum SC of 30 cm, although Kasari et al (33) suggested higher minimums (32 to 33 cm) should be used in breeds such as the Simmental, Angus, and Maine-Anjou. The Western Canadian Association of Bovine Practitioners recommended a minimum SC of 29 cm in Limousin, 30 cm in Hereford and Shorthorn, 31 cm in Charolais and Angus, and 32 cm in Simmental and Gelbvieh bulls at 12 mo of age (4). The recommended minimum acceptable SC for 24 mo old beef bulls were Simmental, 36.0 cm; Angus and Charolais, 35.0 cm; horned and polled Hereford and Shorthorn, 34.0 cm; and Limousin, 33.0 cm (31). Our data confirmed that bulls belonging to these breeds attained above minimum threshold values for SC at 11 to 13 mo and 19 to 26 mo of age under the existing management conditions in Alberta. However, the percentage of bulls with normal sperm cells > 70% did not increase as the age or SC increased, further confirming the reliability of decisions based on BBSE in yearling bulls. Moreover, these data also confirmed the importance of breed-specific recommendations on SC while making decisions on the future fertility and semen production potential of beef bulls (4).

A total of 83% (range 79% to 91%) of bulls subjected to BBSE were satisfactory potential breeders. With increasing age, the percentage of satisfactory potential breeders increased from 79% at 11 to 13 mo of age, to 87% at > 26 mo. In a study involving 2110 beef bulls conducted at the Western College of Veterinary Medicine, Saskatchewan, 65.8% were classified as satisfactory potential breeders (6). The rejection rate on BBSE based on sperm morphology was ~21% between 11 to 18 mo, but it decreased to 14% at 19 to 26 mo. It is very likely that some bulls presented for a BBSE were culled prior to collection of semen, possibly due to inadequate SC or a physical defect. These data were not available from our convenience samples and, therefore, the apparently higher percentage of satisfactory breeders obtained in this study might be due to the exclusion of these data from the study.

Sperm morphology evaluations over the last decade also indicated that there is a tendency for an increase in the proportion of morphologically normal sperm in the ejaculate from beef bulls (34,35). On average, 1 out of every 5 sperm from beef bulls was morphologically abnormal and the most commonly encountered morphological defects in the head, midpiece, and tail region of sperm were detached head, distal midpiece reflex, and bent tail, respectively. Of these defects, distal midpiece reflex was the most common sperm defect.

The differences noticed with respect to the SC in various breeds of bulls in the present study emphasized the importance of considering breed differences for interpreting SC in the BBSE protocol. That 17% of bulls subjected to BBSE were deemed not breeding sound on account of sperm defects emphasized the economic losses attributed solely to sperm morphology.

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