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## Breeding soundness evaluations of Senepol bulls in the US Virgin Islands

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### Abstract

The breeding soundness evaluation (BSE) was used to evaluate Senepol (*Bos taurus*) bulls ( $n = 495$ ) on St. Croix over a 7-year period. Young, unproven bulls (10–26 months of age) and breeding bulls (16 months to 8.5 years) were tested prior to sale or use in breeding. Inbreeding coefficients were determined for a subset of bulls ( $n = 290$ ). The percentage of bulls passing the BSE increased ( $P < 0.0001$ ) with age. Bulls that passed had a higher percentage ( $P < 0.0001$ ) of normal and motile sperm as well as a larger ( $P < 0.0001$ ) scrotal circumference than bulls that failed. No bulls failed the BSE for physical soundness traits or other health reasons. The incidence of testicular hypoplasia was 2.5 and 3.3% and the incidence of cryptorchidism was 1.4 and 0.9% in 12- and 16-month-old bulls, respectively, with no occurrence in bulls >20 months. The proportion of all bulls that failed the BSE and received an Unsatisfactory rating for scrotal circumference or sperm motility decreased ( $P < 0.0001$ ) from >90 to <25% with age. The proportion of all bulls that failed the BSE and received an Unsatisfactory rating for sperm morphology decreased ( $P < 0.0001$ ) from 99 to 83.3% with age. The inbreeding coefficient was higher ( $P < 0.03$ ) in bulls that failed the BSE than in those that passed ( $2.24 \pm 0.19\%$  versus  $1.40 \pm 0.32\%$ , respectively). There was a tendency for bulls with testicular hypoplasia or cryptorchidism to have a higher ( $P = 0.09$ ) inbreeding coefficient than bulls with normal testes ( $2.90 \pm 0.46\%$  versus  $2.13 \pm 0.11\%$ , respectively). In conclusion, Senepol bulls raised under tropical conditions had a low probability of passing the BSE at young ages, but the passing rate increased with age. Older Senepol bulls were more likely to fail the BSE due to abnormal sperm morphology than due to inadequate testicular size or sperm motility. To prevent unnecessary culling, a BSE should not be performed on Senepol bulls <16 months old.

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## 1. Introduction

The breeding soundness evaluation (BSE) is a method of evaluating the potential of a bull to be used as a herd sire [1–3]. The BSE consists of evaluating scrotal circumference (SC), semen quality, physical soundness, and overall health of the bull. Semen quality is further categorized into progressive motility and sperm morphology. In an earlier version of the BSE [1], points were assigned for each trait and a bull was assigned a total score, which was the sum of points for each trait. A score of 60 or greater was considered Satisfactory, bulls that scored between 30 and 59 were considered to be Questionable Breeders and bulls scoring below 30 were considered Unsatisfactory. The BSE has since been revised by the Society for Theriogenology [2,3] and now utilizes minimum acceptable levels of each trait to evaluate a bull instead of assigning points for each trait. A minimum scrotal circumference was established for age categories, with the lowest being 30 cm at 12–15 months of age. Sperm morphology must be at least 70% normal with at least 30% progressive motility. For a bull to be classified as a Satisfactory Potential Breeder, it must meet or exceed the minimum requirements for each trait. Bulls that do not meet or exceed these threshold values are classified as Unsatisfactory Potential Breeders or Classification Deferred [2,3]. When a bull does not meet the minimum semen requirements, the bull can be re-tested at a later date.

Although BSE threshold values for minimum SC do not discriminate based on breed, there can be considerable differences in SC across breeds at a certain age. The threshold levels of SC and semen traits were established using Continental and English breeds of *Bos taurus* cattle. Bruner et al. [4] reported that Simmental bulls had a larger SC than Angus, Charolais and Polled Hereford bulls at 11–15 months of age. Even with the differences in SC, there were no differences among breeds in BSE score [4] using the older BSE scoring system that may have been due to variation in the semen quality of the bulls that compensated for differences in SC. Another possibility is that the SC standards used were too low for some of the breeds evaluated. Coulter et al. [5] suggested that the minimum acceptable SC for 2-year-old bulls should be breed specific with adjustments made for breeds that reach sexual maturity later. The recommended minimum SC for 12–14 months old Simmental, Angus and Charolais, and Hereford bulls was 33, 32 and 31 cm, respectively.

There are few data available on the evaluation of Senepol bulls using the BSE [5]. The Senepol is a *B. taurus* breed that was developed on St. Croix in the US Virgin Islands during the early 1900s by crossing N'Dama and Red Poll cattle and selecting for animals that were able to tolerate the tropical climate and forages of the island. Because much of the developmental work done with the BSE was done in *B. taurus* breeds in temperate regions, it may not be as applicable to the Senepol cattle raised under the semi-arid, tropical conditions found on St. Croix. The objective of the present study was to determine the percentage of Senepol bulls that passed the BSE at various ages. The level of inbreeding within the isolated herds on St. Croix was also evaluated to determine if there was a relationship between the BSE results and inbreeding in the Senepol bulls.

## 2. Materials and methods

Senepol bulls on three farms on St. Croix, US Virgin Islands were evaluated using the scoring system of the breeding soundness evaluation as described by the Society for Theriogenology [2,3]. Evaluations were done over a 7-year period beginning in 1995. Bulls ( $n = 495$ ) ranged in age from 10 months to 8.5 years; a total of 835 BSE tests were conducted (Table 1). Evaluations were conducted on each farm at 4-month intervals throughout the year (March, July and November) from 1998 through 2002. All bulls between 10 and 26 months of age that were on the farm each test day were evaluated. Other bulls included in the data (16 months to 8.5 years of age) were evaluated randomly throughout the year between 1995 and 2002, prior to sale or use for breeding, at the request of the owner. For this study, the Classification Deferred rating was not used and bulls were given a rating of either Satisfactory or Unsatisfactory, based on the BSE guidelines [2,3].

In addition to evaluating physical soundness and general animal health, measurements collected included SC and sperm motility and morphology. Semen samples were collected by electroejaculation. Sperm motility was evaluated in an undiluted aliquot of the ejaculate immediately after collection at the farm with a microscope at 100 and 400 $\times$  on a warm slide. An aliquot of neat semen (10  $\mu$ L) was diluted with formalin (1.99 mL) and taken back to the lab for the evaluation of sperm morphology at 400 $\times$ , using previously described methods [7]. If a bull younger than 15 months had a SC less than the minimum 30 cm necessary for a Satisfactory rating (as prescribed in the BSE guidelines), semen was not collected. Bulls older than 15 months had semen collected regardless of SC. Inbreeding coefficients were determined for a subset of bulls (Table 1) using Pedigree Viewer 5.0 software [Brian Kinghorn, University of New England, Armidale, New South Wales, Australia; <http://www-personal.une.edu.au/~bkinghor/>] and pedigree information obtained from the owners of the bulls.

Prior to statistical analysis, BSE results were grouped by age of the bull at the time of testing. The age groups were 12 months ( $\geq 10$  and  $\leq 14$  months), 16 months ( $>14$  and  $\leq 18$  months), 20 months ( $>18$  and  $\leq 22$  months), 24 months ( $>22$  and  $\leq 26$  months), and  $>26$  months ( $>26$  months). The bulls tested randomly throughout the year tended to be older and, based on genetics or production records, had been previously selected by their owners

Table 1  
Number of BSE tests and Senepol bulls tested within each age group for all bulls tested and the subset of those with inbreeding coefficient (IC) calculations

Age group (months) <sup>a</sup>	All bulls	Bulls with IC calculations
12	356	237
16	210	165
20	105	71
24	50	35
>26	114	37
Total number of BSE tests	835	545
Number of bulls evaluated	495	290

<sup>a</sup> Age groups were 12 months:  $\geq 10$  and  $\leq 14$  months, 16 months:  $>14$  and  $\leq 18$  months, 20 months:  $>18$  and  $\leq 22$  months, 24 months:  $>22$  and  $\leq 26$  months and  $>26$  months:  $>26$  months.

for use as herd sires or for sale as breeding animals. The mean and median for this age group of bulls were 42.2 and 36.4 months, respectively with 68.6% of them being in the >26 months of age group. Data were analyzed using General Linear Models procedures of SAS [8] to analyze BSE traits and IC. Independent terms included in the model initially were farm, year, BSE rating and age group. Farm and year were non-significant and therefore were excluded from the model for the final analysis. Mean separation tests were conducted using the PDIFF option of SAS [8]. All values are reported as least squares mean  $\pm$  S.E. Correlation analysis [8] was done to determine the relationship between the values of SC, sperm motility and sperm morphology and IC of bulls within age groups. Chi-square analysis [8] was used to determine the proportions of bulls within age groups that received Satisfactory or Unsatisfactory BSE ratings.

### 3. Results

The incidence of testicular hypoplasia, determined based on visual appraisal of the testes at the time of SC measurement, was 2.5 and 3.3% and the incidence of cryptorchidism was 1.4 and 0.9% in 12- and 16-month-old bulls, respectively, with no occurrence of either condition in older age groups. No bulls failed the BSE due to physical soundness problems of the feet and legs, poor body condition, or disease.

The percentage of bulls passing the BSE increased ( $P < 0.0001$ ) with age, ranging from 2.3 to 68.4% (Fig. 1). Of the bulls that failed the BSE, the proportion that failed three traits (SC, sperm motility and morphology) decreased from 90.5% in the 12 months group to 0% in the >26 months group, but the proportion that failed just one trait increased from 5.2 in

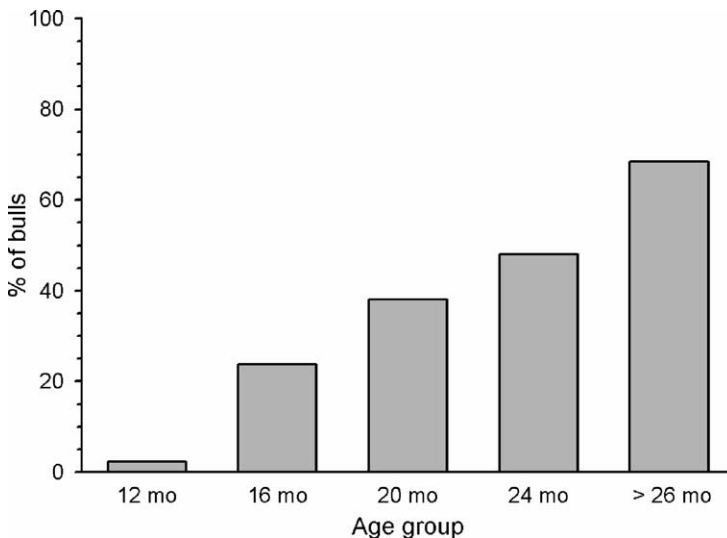


Fig. 1. The proportion of Senepol bulls within age groups that received a Satisfactory BSE rating increased with age ( $P < 0.0001$ ). The age of bulls within each group are: 12 months:  $\geq 10$  and  $\leq 14$  months, 16 months:  $> 14$  and  $\leq 18$  months, 20 months:  $> 18$  and  $\leq 22$  months, 24 months:  $> 22$  and  $\leq 26$  months and >26 months:  $> 26$  months.

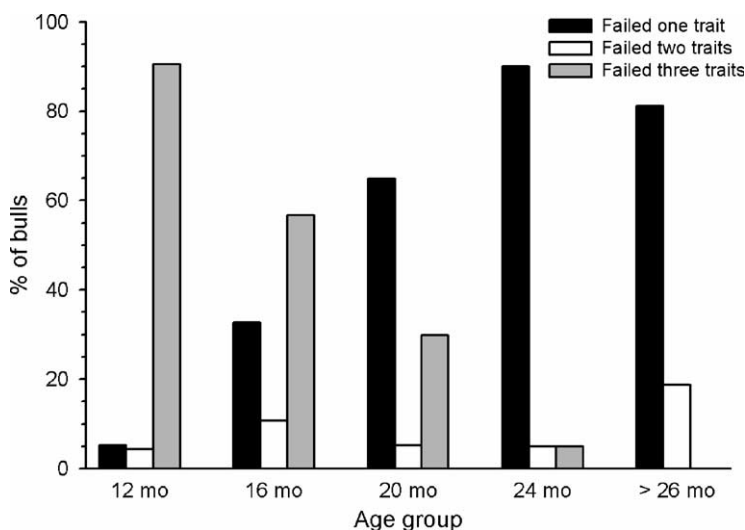


Fig. 2. The proportion of Senepol bulls within age groups that received an Unsatisfactory BSE rating and an Unsatisfactory rating for one, two or three of the BSE traits. The percentage of bulls receiving an Unsatisfactory rating for one trait increased with age, while the proportion of bulls receiving an Unsatisfactory rating for three traits decreased across age ( $P < 0.0001$ ). The age of bulls within each group are: 12 months:  $\geq 10$  and  $\leq 14$  months, 16 months:  $> 14$  and  $\leq 18$  months, 20 months:  $> 18$  and  $\leq 22$  months, 24 months:  $> 22$  and  $\leq 26$  months and  $> 26$  months:  $> 26$  months.

the 12 months group to 90.0% in the 24 months group ( $P < 0.0001$ ; Fig. 2). The proportion of bulls that failed two of the three traits remained below 20% across the age groups.

The proportion of bulls that received an Unsatisfactory BSE rating and an Unsatisfactory rating for SC decreased ( $P < 0.0001$ ) from 90.8% in the 12 months group to 19.4% in the  $> 26$  months group (Fig. 3). The proportion of bulls that received an Unsatisfactory BSE rating and an Unsatisfactory rating for sperm motility decreased ( $P < 0.0001$ ) from 95.1% in the 12 months group to 11.5% in the 24 months group (Fig. 3). The proportion of bulls that received an Unsatisfactory BSE rating and an Unsatisfactory rating for sperm morphology decreased ( $P < 0.0001$ ) from 99.4% in the 12 months group to 73.1% in the 24 months group (Fig. 3). The proportion of Unsatisfactory bulls receiving an Unsatisfactory SC or sperm motility rating decreased to less than 25% in the  $> 26$  months age group, but the proportion of these bulls with an Unsatisfactory rating for sperm morphology was 83.3% in the  $> 26$  months age group (Fig. 3).

Bulls rated as Satisfactory had higher ( $P < 0.002$ ) SC than Unsatisfactory bulls within all age groups (Table 2). Percent motile sperm was higher in Satisfactory bulls than in Unsatisfactory bulls in the 12 ( $P < 0.03$ ), 16 ( $P < 0.002$ ) and  $> 26$  months ( $P < 0.03$ ) groups. The percentage of normal sperm was higher ( $P < 0.0001$ ) in Satisfactory bulls than in Unsatisfactory bulls at all ages. When the BSE results were pooled across age groups, bulls receiving a Satisfactory BSE rating had larger SC and higher percentages of motile and normal sperm ( $P < 0.0001$ ) than Unsatisfactory bulls (Table 2).

Mean, medium, minimum and maximum IC of the subset of 290 bulls were 2.19, 1.50, 0.0 and 27.2%, respectively with only 2.2% of the bulls having an IC above 10%.

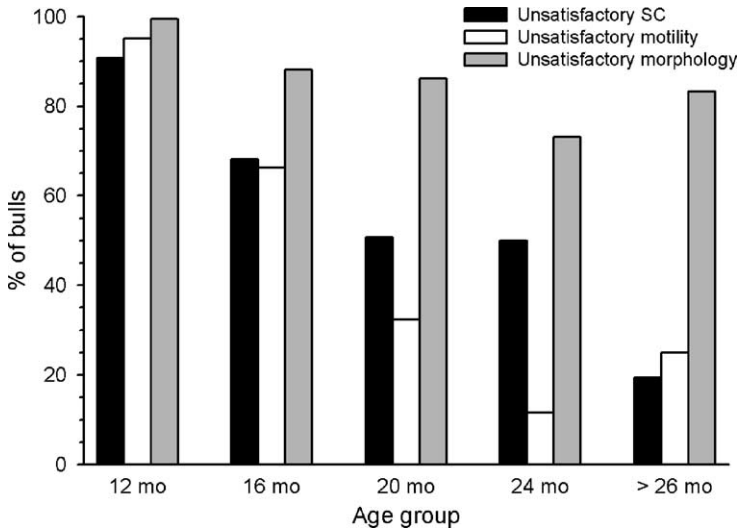


Fig. 3. The proportion of Senepol bulls within each age group that received an Unsatisfactory BSE rating and an Unsatisfactory rating for SC, sperm motility or sperm morphology. The percentage of bulls that received an Unsatisfactory score for SC, sperm motility or sperm morphology decreased ( $P < 0.0001$ ) across age groups. The age of bulls within each group are: 12 months:  $\geq 10$  and  $\leq 14$  months, 16 months:  $> 14$  and  $\leq 18$  months, 20 months:  $> 18$  and  $\leq 22$  months, 24 months:  $> 22$  and  $\leq 26$  months and  $> 26$  months:  $> 26$  months.

Inbreeding coefficient was higher ( $P < 0.03$ ) in bulls that failed the BSE than in those that passed ( $2.24 \pm 0.19\%$  versus  $1.40 \pm 0.32\%$ , respectively). There was a tendency for bulls with either testicular hypoplasia or cryptorchidism to have a higher ( $P = 0.09$ ) IC than bulls with normal testes ( $2.90 \pm 0.46\%$  versus  $2.13 \pm 0.11\%$ , respectively). Inbreeding coefficient had a low to moderate negative correlation with SC ( $P = 0.0008$  to  $0.05$ ,  $r = -0.53$  to  $-0.13$ ) and sperm motility ( $P = 0.03$  to  $0.07$ ,  $r = -0.44$  to  $-0.29$ ) among

Table 2

Traits (LSM  $\pm$  S.E.) of Senepol bulls within age categories based on results of the BSE

Age group (months) <sup>a</sup>	SC (cm)		Motility (%)		Normal morphology (%)	
	Satisfactory	Unsatisfactory	Satisfactory	Unsatisfactory	Satisfactory	Unsatisfactory
12	33.6 $\pm$ 1.1 <sup>b</sup>	26.5 $\pm$ 0.2 <sup>c</sup>	80.0 $\pm$ 7.4 <sup>d</sup>	60.5 $\pm$ 4.7 <sup>e</sup>	81.9 $\pm$ 3.6 <sup>f</sup>	55.9 $\pm$ 2.3 <sup>g</sup>
16	33.7 $\pm$ 0.4 <sup>b</sup>	29.9 $\pm$ 0.2 <sup>c</sup>	83.5 $\pm$ 2.9 <sup>b</sup>	68.8 $\pm$ 2.6 <sup>c</sup>	80.9 $\pm$ 1.4 <sup>f</sup>	66.1 $\pm$ 1.3 <sup>g</sup>
20	35.1 $\pm$ 0.5 <sup>b</sup>	31.9 $\pm$ 0.4 <sup>c</sup>	86.2 $\pm$ 3.3	81.1 $\pm$ 3.0	84.4 $\pm$ 1.6 <sup>f</sup>	63.4 $\pm$ 1.5 <sup>g</sup>
24	37.4 $\pm$ 0.6 <sup>b</sup>	34.5 $\pm$ 0.6 <sup>c</sup>	84.6 $\pm$ 4.3	78.8 $\pm$ 4.2	85.2 $\pm$ 2.1 <sup>f</sup>	65.7 $\pm$ 2.0 <sup>g</sup>
>26	39.9 $\pm$ 0.3 <sup>b</sup>	38.0 $\pm$ 0.5 <sup>c</sup>	82.6 $\pm$ 2.4 <sup>d</sup>	72.0 $\pm$ 3.7 <sup>e</sup>	83.6 $\pm$ 1.1 <sup>f</sup>	60.8 $\pm$ 1.9 <sup>g</sup>
Pooled	35.9 $\pm$ 0.3 <sup>f</sup>	32.2 $\pm$ 0.2 <sup>g</sup>	83.4 $\pm$ 1.9 <sup>f</sup>	72.2 $\pm$ 1.7 <sup>g</sup>	83.2 $\pm$ 0.9 <sup>f</sup>	62.4 $\pm$ 0.8 <sup>g</sup>

Values within age group (row) and within BSE trait (column) with different superscripts differ: <sup>b,c</sup>( $P < 0.002$ ), <sup>d,e</sup>( $P < 0.03$ ), <sup>f,g</sup>( $P < 0.0001$ ).

<sup>a</sup> Age groups were 12 months:  $\geq 10$  and  $\leq 14$  months, 16 months:  $> 14$  and  $\leq 18$  months, 20 months:  $> 18$  and  $\leq 22$  months, 24 months:  $> 22$  and  $\leq 26$  months and  $> 26$  months:  $> 26$  months.

Table 3  
Correlation of inbreeding coefficient with BSE traits of Senepol bulls tested at several ages

Age group (months) <sup>a</sup>	BSE trait		
	SC	Motility	Morphology
12	−0.13 (0.05)	−0.44 (0.05)	0.002 (0.99)
16	−0.15 (0.06)	0.004 (0.97)	0.07 (0.52)
20	−0.19 (0.11)	−0.29 (0.03)	−0.08 (0.56)
24	−0.28 (0.10)	−0.12 (0.48)	0.18 (0.35)
>26	−0.53 (0.0008)	−0.30 (0.07)	−0.02 (0.93)
Pooled	−0.16 (0.0002)	−0.13 (0.06)	−0.02 (0.8)

Values represent correlation coefficient, *r*, and (*P*).

<sup>a</sup> Age groups were 12 months:  $\geq 10$  and  $\leq 14$  months, 16 months:  $>14$  and  $\leq 18$  months, 20 months:  $>18$  and  $\leq 22$  months, 24 months:  $>22$  and  $\leq 26$  months and  $>26$  months:  $>26$  months.

age groups (Table 3). Sperm morphology was not correlated ( $P > 0.10$ ) with IC at any age. When pooled across ages, IC had a low, negative correlation with SC ( $P < 0.0002$ ) and sperm motility ( $P < 0.06$ ) but not sperm morphology ( $P > 0.10$ ; Table 3).

#### 4. Discussion

Chenoweth et al. [6] reported that Senepol bulls in Florida exhibited an increase in the percentage passing the BSE with increasing age. They reported that bulls aged 15, 18 or 22 months had Satisfactory BSE ratings of 16, 59 and 74%, respectively. These values seemed higher than those of the bulls in the present study (Fig. 1). The apparent difference in passing rate within age groups may be due to the range of ages used for the groupings in the current study ( $\geq 10$  and  $\leq 14$  months,  $>14$  and  $\leq 18$  months and  $>18$  and  $\leq 22$  months) compared to the ranges ( $\leq 15$  months, 15.1–18 and 18.1–22 months) used by Chenoweth et al. [6]. The latter groups would correspond, but not exactly due to overlap, to the 12, 16 and 20 months groups of the present study. Even though the percentage of bulls passing seemed lower than in the previous study [6], the pattern of an increase with age was similar. In a study by Wildeus and Fugle [9], young Senepol bulls at 12, 16, 20 and 24 months of age had SC of 27, 30, 33 and 35 cm and Larsen et al. [10] reported that 2-year-old Senepol bulls had an average SC of 34.7 cm and Senepol bulls  $>3$  years had a mean SC of 37.9 cm. With the exception of the 12 and 16 months groups, the values were close to the mean SC for 20, 24 and  $>26$  months bulls, pooled across BSE rating, in the present study (33.5, 35.9 and 38.9 cm, respectively).

The SC of Senepol bulls at 12 months of age (27 cm) reported previously [6,9] seemed lower than the mean SC of all bulls pooled across BSE rating, in the 12 months group in the present study and below the threshold value to pass the BSE at that age [2,3]. The bulls in the 16 months group, pooled across BSE rating, had an average SC above the BSE threshold for that age, but 16 months old Senepol bulls in other studies [6,9] had mean SC of 30 cm which is below the BSE threshold [2,3]. The reasons for the differences between these studies and the present one could be related to animal management and nutrition,

although the animals used by Wildeus and Fugle [9] were located on St. Croix and would have been exposed to similar management and environmental conditions as the bulls in the present study.

Even with variation in ages and breed, Kennedy et al. [11] concluded that it is feasible to test yearling bulls using the BSE because up to 80% of the bulls tested were classified as Satisfactory. In contrast, Arteaga et al. [12] reported that only 41–61% of *B. taurus* bulls tested at 11–15 months of age had sperm morphology above the BSE threshold. Even comparing the results of the present study with the contrasting results of these two studies, the 2.25% passing rate observed for yearling Senepol bulls was low. Carson and Wenzel [13] reported that 71% of Senepol tested, regardless of age, passed the BSE. Because age of the Senepol bulls was not indicated in the previous study [13] it is difficult to compare the results to those of the present study, but the only group that had a comparable passing rate was the >26 months group with a passing rate of 68.4%.

Morris et al. [14] studied Brahman bulls and proposed the development of a separate scoring system for evaluating SC of these bulls. The Brahman, a *Bos indicus* breed, is known for its tropical adaptation, as is the Senepol, a *B. taurus* breed. Previous studies [6,14], along with the present study, indicate that there may be a need to utilize separate evaluation systems for tropically adapted breeds of *B. taurus* and *B. indicus* cattle. Another option would be to delay the age of first conducting a BSE on Senepol bulls. Because yearling Senepol bulls and *B. indicus* bulls have smaller SC compared to similarly aged European and Continental *B. taurus* bulls [6], it may not be appropriate to conduct a BSE on these bulls when they are yearlings. Based on the present work and previous studies [6,9,14], it may be more appropriate to begin testing Senepol bulls at 16 months of age using the BSE.

Since older bulls were more often classified as Unsatisfactory due to failure of only one component of the BSE (Fig. 2) and a higher proportion of the older bulls receiving an Unsatisfactory BSE rating had poor sperm morphology than a low SC or sperm motility rating (Fig. 3), poor sperm morphology appeared to have more impact on the ability of a bull to pass the BSE than either SC or sperm motility, and was more critical as age increased. In agreement with this, Kennedy et al. [11] reported that the two traits most often resulting in a bull receiving a classification of Unsatisfactory were inadequate sperm morphology or SC. Further supporting the impact of sperm morphology on BSE rating, Arteaga et al. [12] reported that only 61% of *B. taurus* bulls tested at 15 months of age had sperm morphology above the BSE threshold, but 92% had sperm motility values above the threshold. Although there was no indication of the proportion of bulls that had SC values above the threshold at this age, the mean (35.3 cm) was above the threshold value. Larsen et al. [10] noted that semen score, a combination of a subjective motility rating and sperm morphology, was a better predictor of fertility in bulls with a SC greater than the threshold value. Even though bull fertility was not evaluated in the present study, the results were in agreement with previous studies [10–12] that reported the importance of sperm morphology in evaluating the breeding potential of a bull whether using the BSE or other indicators.

The low incidence of bulls with testicular hypoplasia or cryptorchidism was in agreement with Carson and Wenzel [13] who observed cryptorchidism in just 0.61% of the bulls tested. In the current study, the low number of bulls with these undesirable traits ( $n = 7$  cryptorchid;  $n = 16$  hypoplastic) were culled at an early age and removed from the



herds, which explains why the conditions were not found in older bulls. The tendency for bulls with these traits to have higher IC may not be significant because of the low average IC in the herd (2.19%) and the low number of bulls with these traits. The lower IC in bulls rated Satisfactory compared to Unsatisfactory bulls may not be biologically significant either, due to the low overall average IC and the difference was only 0.84. There is a paucity of information in the literature relating the level of bull inbreeding to their BSE rating, regardless of breed. More work needs to be done in this area before definitive conclusions can be made.

In conclusion, a low proportion of young Senepol bulls were able to achieve a Satisfactory BSE rating, but the proportion increased substantially with age, consistent with other breeds. Older bulls usually failed the BSE because of just one trait; that trait was more likely to be poor sperm morphology than poor sperm motility or low SC. The low level of inbreeding in the Senepol herds on St. Croix did not have a major effect on the breeding potential of the bulls evaluated using the BSE. It is recommended that a BSE not be conducted on Senepol bulls < 16 months of age, to avoid rejecting too many young bulls for use as potential breeding animals.

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