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Full Length Research Paper

Testicular development and relationship between body weight, testis size and sperm output in tropical boars

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Ten boars selected from each group of local Nigerian (LNB), Large White (LW) and LNB x LW (F1) crossbred boars were studied to determine the pattern of testicular development by external testicular measurements (length and width of testis) and to find out the relationship between external testicular dimensions body weight and sperm output. The results showed that LW boars were superior to both LNB and LNB x LW (F1) boars in all testicular and body weight measurements, while LNB x LW (F1) boars showed remarkable improvement over the LNB parent in all measurements. Rapid growth of the testis occurred in LNB from 14 – 30 weeks of age and 14 – 32 weeks of age in the crossbreds. Rapid growth of testis occurred from 12 – 32 weeks in the LW boars. These periods coincided with the phase of rapid gain in body weight in the various groups. Significant ($P < 0.05$) between genotype differences were observed in body weight and testicular measurements. Sperm output/48h was highest in LW boars and lowest in LNB boars. Correlations between body weight testicular measurements and sperm output per 48 h were positive and highly significant ($P < 0.01$) in all groups with r^2 value ranging from 0.74 – 0.90. Sperm output was highly correlated ($P < 0.01$) with body weight in all genotypes with r^2 values ranging from 0.85 – 0.91. The results generally indicate that measurements of external testis dimensions, body weight and sperm output characteristics can accurately guide the assessment of the reproductive performance of boars.

Key words: Testis size, body weight, sperm output, boars.

INTRODUCTION

A major determinant of the reproductive performance of boars is the growth pattern and ultimate size of the testis. This may be because lines or crosses that have larger testes at a constant age generally have greater sperm numbers and superior mating efficiency (Neely et al., 1976; Wilson et al., 1977; Schinkel et al., 1983). Significant breed and heterosis effects on testicular development have been earlier reported in pubertal boars of temperate origin (Hauser et al., 1952; Fent et al., 1983). In those studies, crossbred boars were found to be superior to their purebred counterparts with respect to weight of testes, epididymides and testicular sperm numbers. Thus, wide variations tend to exist among breeds and genetic lines of boars in testicular development and mature testis weight (Okwun et al., 1996). Furthermore there appears to be a relationship between the growth of testicular components, absolute testis weight and body weight in boars. There is evidence in literature that the volume percentage occupied by the spermatogenetic tissues increased with age, body weight and testis weight in boars (Allrich et al., 1983; Harder et al., 1995). These reports seem to indicate that boars with higher body and testis weight may produce more spermatozoa. There is, therefore, the need to harmonize body weight, testis size and sperm production capacity in selecting boars for improved reproductive efficiency. However, the use of testis weight as one of the indices in selecting high quality breeding boars would involve either sacrificing or castrating them, which procedure, besides being wasteful in terms of loss of animals of good genetic standing may be of no practical value to the farmer. The present study is therefore designed to determine the pattern of testicu-

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lar growth by external testicular measurements of intact boars and the relationships between body weight, testicular measurements and sperm output in three genotypes of tropical boars.

MATERIALS AND METHODS

The animals and management conditions

Three genotypes namely, Local Nigerian (LNB), Large White (LW) and LNB x LW (F_1) crossbred were used. Twenty weaner boars (8 weeks of age) selected from each of the genotypes reared at the University of Nigeria Animal Research Farm were randomly separated into groups of five and reared intensively in pens measuring 3.5 x 2.5 m^2. The crossbred boars were the first progeny of the cross breeding programme between LNB sires and LW dams through artificial insemination. The average body weights of the three groups were 6.3, 8.5 and 7.4 kg for LNB, LW and LNB X LW (F1). The boars are fed 60% of their line body weigh of a 20% protein diet (Onyimonyi, 2002). Clean water was provided *ad libitum* through out the duration of the experiment

Measurements of body weight and testis

The body weights (BW) of the animals were taken with a sensitive digital scale at day 0 (8 weeks of age) of the experiment and at two weekly intervals until they reached 36 weeks of age. The dimensions (length and width) of each testis were also determined at two weekly intervals using a vernier calipers. Testis length (TL) which is the major axis of the testis is the distance from the top of the testis (Cauda epididymis) to its base (caput epididymis) while the testis width (TW) was measured by adjusting the calipers to span the minor axis of each testis at the point of maximum width. The skinfold thickness (two layers of scrotal skin) was carefully determined along side the dimensional measurements with the calipers. The values obtained were subtracted from initial measurements of TL and TW to obtain the dimensions of testis proper (Hahns et al., 1969). Thereafter, the average measurements (corrected) of TL and TW of both testes were recorded to the nearest 0.01 cm.

Training of boars and semen collection

All *in situ* measurements of the testes were discontinued at 36 weeks of age. Thereafter, boars in all groups were trained daily for semen collection with the dummy and artificial vagina (AV) for three weeks. At 40 weeks of age, ten properly trained boars were selected from each group for semen collection to evaluate quality and determine sperm output per 48 h. Before the actual semen collection, a pre-experimental period of 2 weeks was allowed to stabilize semen yield under the technique adopted. At 41 weeks of age semen was collected routinely per week on Tuesdays, Thursdays and Saturdays for 12 weeks.

Ejaculate assessment

Each ejaculate was subjected to standard visual and microscopic assessment to determine quality in terms of total volume of ejaculate, strained volume of ejaculate, spermatozoa concentration, percentage of sperm with progressive motility, sperm morphology and total number of sperm in one ejaculate. Sperm motility was determined by light microscopy on a warm stage immediately after straining the ejaculate based on the scoring method described by Swierstra (1973). Spermatozoa concentration was determined by hemacytometer counts as described by Melrose (1966) while sperm morphology was evaluated in smears prepared with vital stains (eosin-negrosin) as described by Moore and Hibbitts (1977).

Sperm output

Sperm output per 48 h was estimated in all genotypes using ejaculates collected on Thursdays and Saturdays. The procedure adopted took into consideration the sperm losses in collection equipment (AV and collection bottles) as described by Swierstra and Rahnfeld (1967).

Statistical analysis

The means and standard errors of the means were calculated for body weight testicular measurements and sperm output per 48 h. All data were subjected to completely randomized design based on mathematical model:-

$$Xijk = \mu + ai + eijk$$

Where: xijk = individual observations; μ = population mean; ai = effect of genotype; eijk = error term.

Analysis of variance and correlations among the traits studied were calculated according to procedures described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

The absolute values for testis length (TL), testis width (TW) and body weight (BW) of the three genotypes of boars at various ages are presented in Tables 1, 2 and 3 respectively while the rates of increase in testis dimensions are presented in Figures 1 and 2. The results in Table 1 showed significant ($P < 0.05$) variations in testis length between genotypes. The LW boars exhibited better development of testis length than the other genotypes at various ages followed by the LNB x LW (F_1) boars. The lowest pace of development of testis length was observed in LNB. A similar trend was presented in testis width development in all the genotypes. The crossbred boars showed apparent superiority over the LNB parent in testis length and testis width development. The variations observed among genotypes in TL and TW development were also observed in the body weight of the three genotypes at various ages (Table 3). The LW boars had significantly ($P<0.05$) higher body weight than LNB and crossbreds at various ages while the crossbred performance was better than that of LNB. These results are indicative of the apparent genetic differences between the genotypes and are in consonance with the results reported by Fent et al. (1983) and Schinkel et al. (1983). However, contrary to the observation of Fent et al. (1983) the crossbred boars did not surpass the parental lines in testicular and body development. This may

Table 1. Testis length (cm) in the three genotypes of boars at various ages.

Age (weeks)	LNB	LW	LNB x LW (F$_1$)
8	3.56 ± 0.14^a	4.37 ± 0.16^b	3.96 ± 0.13^a
12	4.32 ± 0.10^a	6.03 ± 0.12^b	5.03 ± 0.16^a
16	5.47 ± 0.14^a	7.54 ± 0.16^b	6.33 ± 0.18^c
20	6.79 ± 0.12^a	9.34 ± 0.13^b	7.85 ± 0.20^c
24	8.12 ± 0.14^a	11.67 ± 0.14^b	9.70 ± 0.18^c
28	0.75 ± 0.15^a	12.55 ± 0.18^b	10.48 ± 0.19^c
32	9.18 ± 0.14^a	12.96 ± 0.16^b	10.86 ± 0.19^c
36	9.46 ± 0.13^a	13.27 ± 0.18^b	11.17 ± 0.15^c

$^{a, b, c}$ Means with different superscript in a row are significantly different (P < 0.05).

Table 2. Testis width (cm) in the three genotypes of boars at various ages.

Age (weeks)	LNB	LW	LNB x LW (F$_1$)
8	1.86 ± 0.09^a	2.95 ± 0.06^b	2.46 ± 0.05^b
12	2.39 ± 0.07^a	3.48 ± 0.05^b	3.12 ± 0.07^b
16	2.95 ± 0.06^a	4.27 ± 0.06^c	3.54 ± 0.06^b
20	3.45 ± 0.08^a	4.96 ± 0.07^b	4.28 ± 0.07^b
24	3.98 ± 0.08^a	5.84 ± 0.07^b	5.18 ± 0.08^b
28	4.49 ± 0.12^a	6.28 ± 0.08^c	5.52 ± 0.07^b
32	4.68 ± 0.10^a	6.43 ± 0.08^b	6.16 ± 0.09^b
36	4.79 ± 0.08^a	6.57 ± 0.07^b	6.22 ± 0.08^b

$^{a, b, c}$ Means with different superscript in a row are significantly different (P < 0.05).

probably be because the authors used genetically improved parental lines while in the present study one of the parents (LNB) is largely unimproved genetically. The best that could be obtained from the crossbreds in this study was the edge they had over the unimproved parent in testicular and body weight development.

As indicated in Figure 1, testis length development was rather slow from 8 – 14 weeks of age in LNB and Crossbred boars and from 8 – 12 weeks in LW boars. Rapid development of testis length was initially evident in LNB and crossbred boars from the 14th week reaching climax in LNB at the 30th week and at 32 weeks of age in the crossbred boars. The LW boars initiated rapid testis length development earlier (12 weeks of age) than the LNB and crossbred boars and attained maximum rate of increase at the 32nd week. Rates of increase in TW development were generally lower than those of TL. Also the absolute values for TW measurements were lower at various ages. However, the trend in TW development (Figure 2) was rather similar to what was observed for TL

Table 3. Body weight (kg) in three genotypes of boars at various ages.

Age (weeks)	LNB	LW	LNB x LW (F$_1$)
8	6.30 ± 0.31	8.50 ± 0.37	7.47 ± 0.29
12	12.58 ± 0.26^a	17.36 ± 0.38^b	15.91 ± 0.33^b
16	19.20 ± 0.28^a	28.42 ± 0.37^b	24.03 ± 0.31^b
20	27.19 ± 0.46^a	40.74 ± 0.54^b	33.69 ± 0.46^c
24	34.65 ± 0.50^a	54.60 ± 0.74^b	45.61 ± 0.55^c
28	41.15 ± 0.68^a	65.10 ± 0.71^b	53.71 ± 0.71^c
32	46.10 ± 0.65^a	74.34 ± 0.88^b	62.39 ± 0.74^c
36	50.13 ± 0.70^a	83.30 ± 0.79^b	69.11 ± 0.80^c

$^{a, ,b, ,c}$ Means with different superscript in a row are significantly different (P < 0.05).

with LNB boars exhibiting maximum rate of TW development at 30 weeks of age while LW and the crossbreds had maximum increase in TW development at 32 weeks of age. These developmental patterns observed for the testes in the genotypes coincided with their respective periods of rapid gain in body weight (Table 3) which also differed significantly (P < 0.05) between genotypes at various ages. The trends in testis development observed in this study were consistent with those reported by van Straaten and Wensing (1977), Franca et al. (2000) who reported similar trend in development of testicular components (germ cells, sertoli cells and Leydig) in Piau pigs. van Straaten and Wensing (1977) indicated that the trend of the quiescent and active developmental stages of the testes coincided with the corresponding stages of development of components of testicular parenchyma. It is evident therefore that the changes that occur in dimensions of testis with age are due to cytological and structural changes in the testes at corresponding ages. This suggests a close relationship between the size of testes at each age and the spermatogenetic and endocrine activities within the testes.

The average values for semen quality traits evaluated (Table 4) indicate that the ejaculates of the various boar genotypes were normal. The semen quality traits differed significantly (P < 0.01) among the boar genotypes with the LNB boars having the lowest values and LW the highest.

The relationships between body weight, testis measurements and sperm output in the three boar genotypes presented in Table 5 showed that body weight and the testicular measurements are highly correlated with sperm output.

These results are in agreement with earlier reports by Allrich et al. (1983) and Harder et al. (1995) implying that heavier boars tend to possess larger testes and may produce more sperm than boars of lower body weight

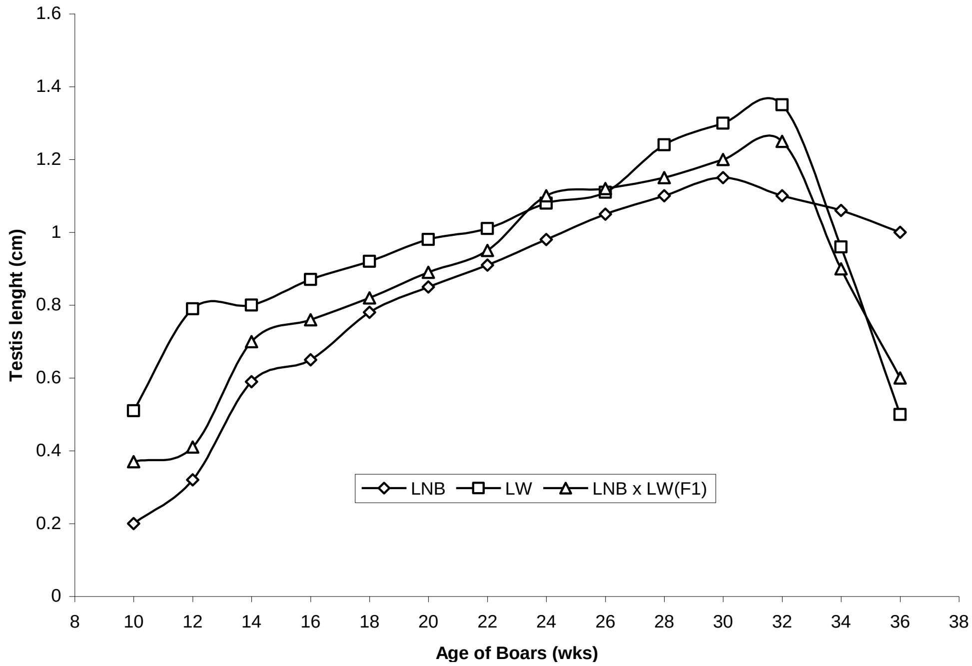

Figure 1. Rates of increase in testis length of boars in the three genotypes at various ages.

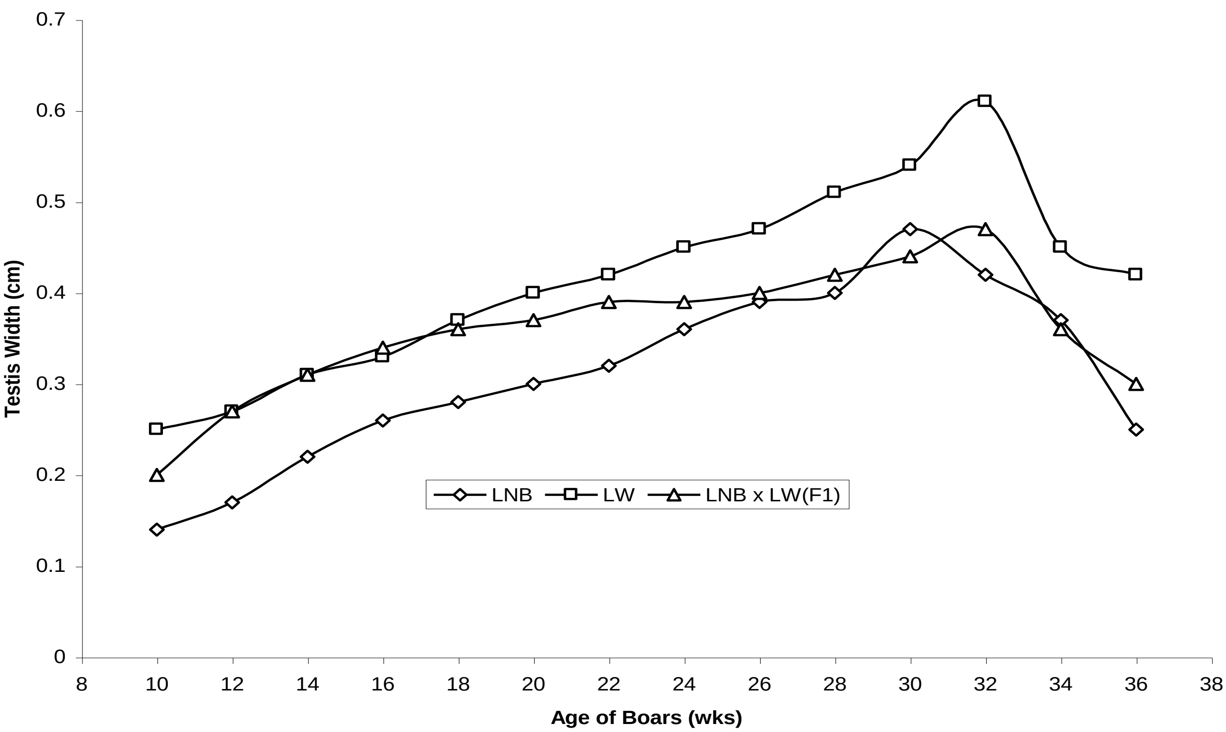

Figure 2. Rates of increase in testis width of boars in the three genotypes at various ages.

and testis size. Our results, therefore suggest that testicular size estimated by external measurements is as much a good indicator of reproductive efficiency in boars as earlier reported by Schinkel et al. (1983). Furthermore

Table 4. Semen quality traits and sperm output per 48 h in the three genotypes of boars.

Trait	LNB	LW	LNB x LW (F_1)
Number of boars	10	10	10
Number of ejaculates	36	36	36
Ejaculate volume (ml)	164.37 ± 3.41[a]	67.56 ± 1.78[c]	149.35 ± 3.82[b]
Strained volume (ml)	132.42 ± 3.61[a]	52.51 ± 2.52[c]	122.85 ± 2.82[b]
Sperm concentration ($X10^6$)	208.86 ± 4.72[a]	160.53 ± 2.52[c]	189.76 ± 3.42[b]
Abnormal sperm morphology (%)	15.5 ± 0.12	16.50 ± 1.38	13.21 ± 1.06
Total sperm in ejaculate ($X10^9$)	31.45 ± 2.03[a]	38.10 ± 1.15[c]	24.97 ± 1.34[b]
Sperm output per 48 h ($X10^9$)	32.58 ± 1.97[a]	38.40 ± 1.35[c]	25.82 ± 1.68[b]

[a, b, c] Means with different superscript in a row are significantly different ($P < 0.05$).

Table 5. Correlation coefficient between body weight, testis measurements and sperm output per 48 h in three genotypes of boars.

	Sperm output per 48 h		
	LNB	LW	LNB x LW (F_1)
Body weight	0.85**	0.90**	0.91**
Testis length	0.86**	0.90**	0.85**
Testis width	0.79**	0.86**	0.80**

** All correlation coefficients are highly significant ($P < 0.01$).

since body weight is also highly correlated with sperm output in the three genotypes, such phenotypic traits as body weight and external testis dimensions can jointly be employed in estimating the reproductive performance of live boars of different genotypes particularly their sperm production capacity.

From the result of the present study, simple testicular measurements can be used to estimate the reproductive performance of boars. This simple technique will save pig breeders the trouble of having to kill or castrate a boar for sole purpose of evaluating reproductive performance.

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REFERENCES

Allrich RD, Christenson RK, Ford JJ, Limmerman DR (1983). Pubertal development in the boar: Age related changes in testicular morphology and *in vitro* production of testosterone and estradiol 17B. Biol. Reprod. 28: 902-909.

Fent RW, Wettemann RP, Johnson RK (1983). Breed and Heterosis Effects on testicular development and endocrine function of pubertal boars. J. Anim. Sci. 57: 425-432.

Franca LR, Silva Jr.VA, Chaiarini-Garcia H, Garcia SK, Debeljuk L (2000). Cell proliferation and Hormonal changes during Postnatal development of Testis in the Pig. Biol. of Reprod. 63: 1629-1636.

Hahns J, Foote RH, Siedel Jr.CE (1969). Testicular growth and related sperm output in dairy bulls. J. Anim. Sci. 29: 41-47.

Harder RR, Lunstra DD, Johnson RK (1995). Growth of testes and testicular morphology after 8 generations of selection for increased predicted weight of testes at 150 days of age in boars. J. Anim. Sci. 73: 2186-2192.

Hauser ER, Dickerson GE, Mayer DT (1952). Reproductive development and performance of inbred and crossbred boars. Missouri Agric. Exp. Sta. Bull. p 503.

Melrose DR (1966). Artificial insemination of Pigs: A review of progress and possible development. World Rev. Anim. Prod. 2: 15-28.

Moore HDM, Hibbitt KB (1977). Seminal plasma protein and reaction of sperm from intact boars and from boars without seminal vesicles to cooling. J. Reprod. Fest. 47: 39-45.

Neely JD, Johnson BH, Robinson OW (1979). Heterosis estimates for measures of reproductive traits in crossbred boars. J. Anim. Sci. 49: 11.

Okwun OE, Igboeli G, Ford JJ, Lunstra DD, Johnson L (1996). Number and function of sertoli cell, number and yield of spermatogonia and daily sperm production in three breeds of boars. J. Reprod. Fert. 107: 137-149.

Onyimonyi AE (2002). Nutritional Evaluation of cassava (*Manihot tillisisma* Pohl) peel and Bambara (*Voandzeia subterranean* Thouars) waste in pig Diets. A Ph. D Dissertation Presented to the Department of Animal Science, University of Nigeria, Nsukka.

Schinkel AR, Johnson K, Pumfrey RA, Zimmerman DR (1983). Testicular growth in boars of different genetic lines and its relationship to reproductive performance. J. Anim. Sci. 56: 1065-1076.

Steel RGD, Torrie JH (1980). Principles and Procedures of Statistics. (2nd Ed) McGraw–Hill Book co. Inc. New York.

Swietstra EE (1973). Influence of breed, age and ejaculation frequency on semen composition in the boar. Can. J. Anim. Sci. 53: 43-53.

Swierstra EE, Rahnfeld GW (1967). Semen and testes characteristics in Yorkshire and Lacombe boars. J. Anim. Sci. 26: 149-157.

Van Straaten HWM, Wensing CJG (1977a). Histomorphometric aspects of testicular morphogenesis in the pig. Boil. Reprod. 17: 473-479.

Wilson ER, Johnson RK, Wettemann RP (1977). Reproductive and testicular characteristics of purebred and crossbred boars. J. Anim. Sci. 44: 939-947.