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Correlations between Sexual Capacity of Boars and Fertility Rates of Mukota, Windsnyer And Kolbroek Sows

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This study was aimed at establishing correlations between sexual capacity of boars and fertility rates of Southern African indigenous sows. Mukota, Windsnyer and Kolbroek pigs' breeds were subjected to sexual preparation procedures of 0MR, 5MR, 10MR, 15MR, 20MR and 25MR. Semen viability and libido were recorded and analysed for sexual capacity and sows were inseminated with semen from sexually prepared boars and analysed for fertility rates. There were significant (P<0.001) correlation observed in libido following 5MR, 10MR and 15MR at a litter size of 15M, motility and semen volume of 0MR. There were significant correlations between libido and normal sperm at 5MR and 10MR while live sperm correlated significantly with libido at all levels following 15MR and 20MR. Litter size at 15MR significantly correlate (P<0.01) with libido following 10MR. Litter size correlated significantly with normal sperm following 5MR, 10MR and 15MR. There were significant correlations in motility and normal sperm following 5MR, 10MR, 15MR and 20MR. There was significant negative correlations observed at r^2=30% amongst the acrosomal morphology. The manifestation of sow fertility is a result of a multifactor interaction of internal and external conditions of the organism; a complex of measures leading to its optimisation can therefore affect it efficiently. Sows inseminated from the boars sexually prepared following 5MR, 10MR during the afternoon recorded highest litter size. However, even though semen viability was higher following 15MR, inseminated sows did not respond similar to those inseminated following 5MR and 10MR in the afternoon. They recorded a decline in litter size between diurnal periods. However, proportions of litter size and sexual capacity increased ranging from 5MR to 15MR during the morning and afternoon.

Keywords: sexual capacity, Mukota, Windsnyer, Kolbroek, boars, fertility, sows

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INTRODUCTION

Differences in the reproductive capacity among boars have been associated with differences in their sexual capacity and semen characteristics in consistent with observations of (Knox, 2016), who speculates that variability in sire fertility can be found on the basis of *in vivo* and *in vitro* fertilization tests, where sires differ in their rate of egg penetration, farrowing rate, and litter size. Knox (2016) indicates that fertility differences

among boars using competitive fertilization tests, where the semen from multiple boars are used to breed females and the paternity of the offspring evaluated. Fertilisation failure can be due to the lack of normal viable sperm reaching the ova. Physical defects or low libido in boars can be a cause of fertilisation failure in a herd. Moreover, percent morphologically normal sperm, an easily measured and moderately to highly repeatable trait in boars once they have reached sexual maturity, has been reported to be one of the main factors affecting litter output of individual boars under multiple sire mating conditions (Burns *et al*., 2010)

MATERIALS AND METHODS

Experimental site

Twelve Southern African indigenous boars (aged 2.0- 4.0 years), consisting of Mukota (n=4), Windsnyer (n=4) and Kolbroek (n=4) and forty-eight sows: Mukota (n=16) Windsnyer (n=16) and Kolbroek (n=16) were randomly selected from communal/tribal areas at the Qwaqwa in Free State, Transkei in Eastern Cape Natal and Agricultural Research Council (ARC) Institute in Irene, Gauteng Province, South Africa. The experimental boars were trained and prepared to mount the sow for the false mount procedure for period of 3 to 6 weeks. Experimental trials were conducted during the period of March 2013 to October 2015. The research protocol was conducted on traditional home designed pig pens of about 6.0m x 3.5m Area, individual pens flooring was soil ground and water and feed (food by-products and leftovers from the kitchens) provided by the owners daily. Nutritional content of the feeds fed was not determined and not known, full description of the management practices of the experimental animals have been reported by Umesiobi (2000) and Umesiobi *et al*. (2004). All the measurements were recorded throughout the duration of this study period which lasted for 32 months.

The experimental boars were acclimated to the test arena and husbandman for two weeks before the first performance evaluation test. The simulation of 30-min sexual preparation protocols was conducted in a 30-min pen test following zero (0MR), five (5MR), ten (10MR), fifteen (15MR), twenty (20MR) and twenty-five (25MR) minutes of sexual restraint at 8h30 and 14h30 diurnal period, and were used to evaluate boar semen and estimate sow fertility using the procedures described earlier by Umesiobi and Iloeje (1999), Umesiobi *et al*. (2004) and Umesiobi (2008a, b, c). Mounting and prompt ejaculation provided a definite, clearly recognisable end point, for establishing that a boar was sufficiently sexually stimulated. Changes of stimulus animals and semen collection location will not commonly be required to stimulate most of the boars or to maintain their sexual interest during teasing (Teele, 2009).

Libido determination

Libido has been defined as the willingness and eagerness of a male to mount and to complete service of female or dummy (Umesiobi *et al.,* 2000; Levis & Reicks, 2005). Mating ability has been defined as the ability to perform complete service conditioned by the anatomical structure of the male and the copulatory organs (Willenburg *et al.,* 2003). Therefore, mating ability presupposes a certain amount of libido. Libido is assessed during semen collection, using libido, false mounting and sexual restraint. Libido is measured by the libido (i.e. the time in minutes from introduction of the boar to the teaser to the time of first mounting), using the procedures described earlier by Umesiobi and Iloeje (1999) and Umesiobi *et al.* (2004). The three levels of sexual teasing were attained by restraining the boars 20 for zero (0R), 5 (5R) and 10 (R) minutes sexual restraint respectively in line with the procedures of Umesiobi and Iloeje (1999). Mounting and prompt ejaculation provided a definite, clearly recognisable end point, for establishing that a boar was sufficiently sexually stimulated. Changes of stimulus animals and semen collection location were not commonly required to stimulate most of the boars or to maintain their sexual interest during teasing.

Semen viability measurements

Increasing use of assisted reproductive techniques in the pig has exposed a need for additional aids such as sexual preparation of boars to help animal reproductive physiologists optimize the ejaculates obtained from boars. Specifically, improving upon the number of spermatozoa obtained during semen collection would benefit most areas of assisted reproduction, including semen preservation and artificial insemination. Although some boars consistently give high quality semen samples when collected for semen evaluation, or insemination, other boars are more difficult to collect and give ejaculates with low numbers of sperm and other suboptimal semen characteristics (Umesiobi & Iloeje., 1999; Umesiobi, 2004). The volume of the sperm-rich fraction of the ejaculate was measured in a graduated cylinder and sperm concentration measured with a hemacytometer using procedure. To evaluate the motility and the movement quality, two subsamples were placed on warm glass slides (39^0C) and examined under a light microscope 400=magnification. The percentage of motile sperm cells was estimated subjectively to the nearest 5% using an arbitrary scale of 0–5. Wet mounts of semen fixed in buffered 2% glutaraldehyde solution were examined under a phase-contrast microscope 1000=magnification to analyze morphology and acrosomes (Gadea *et al*., 1998). An eosin/nigrosine (EN)

stained smear was prepared immediately after thawing and sperm morphology was evaluated by examining 200 sperm, under magnification 1000with bright-field microscopy.

Spermatozoon and Acrosomal morphology evaluation

The integrity of plasma and acrosomal membranes, as well as mitochondrial function, were evaluated using a combination of propidium iodide (PI), fluorescein isothiocyanate conjugated Pisumsativum agglutinin (FITC-PSA), and 5,5',6,6'-tetrachloro- 1,1',3,3'-tetraethylbenzimidazolcarbocyanine iodide (JC-1) fluorescent probes, respectively (Selcuk & Akal, 2015). Acrosome integrity was determined by mixing a droplet of semen sample with a droplet of 0.2% glutaraldehyde on a warm slide, applying a coverslip, and examining 100 sperm under magnification 1000with phase-contrast microscopy using Brito *et al.* (2003) procedure. The proportion of spermatozoa with a normal apical ridge (NAR), damage apical ridge (DAR), loose acrosomal cap (LAC) and missing apical ridge (MAR) were determined on two slides per sample and a total of 300 spermatozoa per sample using procedure described by (Umesiobi, 2004). Two hundred spermatozoa were categorized according to sperm morphology into those with normal morphology, cells with attached cytoplasmic droplets, folded tail, coiled tail and others abnormal heads, etc. Eosin–nigrosin viability staining of sperm was applied. A semen sample was diluted 1:1 with staining solution 5% eosin, 10% nigrosin in a citrate solution pHs 7.4 and smeared. Air-fixed stained spermatozoa were observed and 200 sperms were evaluated per slide.

Sow fertility measurements

Oestrus detection

Individual sows on heat were visually assessed for signs of oestrous twice daily during check-up periods during 08:30 in the morning and 14:30 in the afternoon from the third day after weaning onwards; where each sow was tested with the teaser boar from the boar pen to check should a sow showed the standing response when mounted. When the sow had shown this response, during following check-up periods the sow was tested with the backpressure test in absence of the boar before insemination.

Pregnancy/ fecundity rate

Fecundity rate was defined as the proportion of non-return to service (pregnant) females over the total number of females that were serviced by the males during AI procedures (Umesiobi *et al*., 2000). In this study fecundity rate was measured by farrowing rate which is the percentage of sows that farrowed piglets over the number that were mated/ inseminated. Where farrowing (non-return) rate (FR) was calculated as a percentage of dividing the number of mated (inseminated) sows (MP) over the number of non-return sows (NR), where return rate (RR) was calculated as a percentage of dividing number of return sows (RP) by number of mated sows (MP)

Farrowing rate $(FR) = \sum NR \div \sum MP \times 100$
Where:

NR = Total number of non-return (*n* = 34)
- Mukota number of non-return (*n* = 11)
- Windsnyer number of non-return (*n* = 9)
- Kolbroek number of non-return (*n* = 14)

MP = Total number of mated sows (*n* = 48)
- Mukota number of mated sows (*n* = 16)
- Windsnyer number of mated sows (*n* = 16)
- Kolbroek number of mated sows (*n* = 16)

Return rate $(RR) = \sum RP \div \sum MP \times 100$
Where:

RP = Total number of return sows (*n* = 14)
- Mukota number of return sows (*n* = 5)
- Windsnyer number of return sows (*n* = 7)
- Kolbroek number of return sows (*n* = 2)

Litter size

Litter size was calculated as the number of piglets farrowed by a sow following a gestation period. From the total number of piglets born the total number of piglets that died were recorded as dead piglets and their rate were determined as mortality rate. Where mortality rate (MR) was calculated as a percentage of dividing the number of dead piglets (DPg) over the number of born piglets (BPg)

Mortality rate $(MR) = \sum DPg \div \sum BPg \times 100$
Where:

DPg = Total number of dead piglets (*n* = 12)
- Mukota number of dead piglets (*n* = 3)
- Windsnyer number of dead piglets (*n* = 5)
- Kolbroek number of dead piglets (*n* = 4)

BPg = Total number of born piglets (*n* = 96)
- Mukota number of born piglets (*n* = 37)
- Windsnyer number of born piglets (*n* = 24)
- Kolbroek number of born piglets (*n* = 35)

Weaning weight of piglets

The type of weaning method used in the areas of research are inherently conventional weaning methods where sows will wean their own piglets on their own without interference of the outside force like in other methods used in commercial and semi-commercial systems. In this study, piglets were weaned between five (5) and seven (7) weeks. The piglets were weighed following weaning period and their weight was recorded.

Statistical analysis

Differences in fertilization rates among boars were evaluated by chi-square and differences in sperm viability among boars were evaluated by Kruskal–Wallis one-way ANOVA. Linear regressions for fertility rate were determined, using results from sperm viability tests as independent variables. Stepwise regression analysis was performed to determine the best-fitting regression model for fertility rates using the independent variables that showed a significant linear regression (Brito *et al*., 2003). Sow parity, number of total born (stillborn & live born), number of live born, and equalized litter size was assumed normally distributed and analysed using the MIXED procedure of SAS with treatment as fixed effect. Analysis of total born and analyses of live born and equalized litter size included both parity and total born as fixed effects. The analysis of stillborn piglets the number of total born piglets per litter was included as fixed effect. In addition, the effect of farrowing duration (<5h, 5-9h or >9 h) on stillborn piglets and live born mortality before equalization were analysed. As the data was discrete, it was analysed using the GENMOD procedure with an underlying poisson distribution. These models included treatment, parity and total born as fixed effects, and the corresponding interaction terms using procedure described by Hales *et al.* (2015).

Estimated least squares means and corresponding standard deviation are presented for the normally distributed data. For the square root transformed data the back-transformed estimates are presented with a 95% confidence interval and for the poisson distributed data the back-transformed means and standard deviation are presented. Pregnancy rate was recorded as non-return rate or farrowing rate of the sows. An independent variable had to have a probability *P<0.01, P<0.001* to be included in the model, allowing detection of relationships which, while not significant at the *P<0.05* level, may indicate trends of biological importance. The correlation coefficient functions were determined as follow;

y = vector of values of the dependent variable (observed)
yf= fitted values
Error vector, e= y – yf

Sum of squared errors (SSE):

$$SSE = \sum_{i-1}^{n} y_i - yf_i$$

Sum of squared totals:

$$SST = \sum_{i-1}^{n} (y_i - \overline{y})^2$$

where $\bar{y}$ is the mean value of y.

The correlation coefficient is

$$r = \sqrt{1 - \frac{SSE}{SST}}$$

Correlation coefficient was simplified by squaring the r to r^2

$$\left(r = \sqrt{1 - \frac{SSE}{SST}} \right)^2$$

The closer r is to +1 or -1, the more closely the two variables are related. Where r is close to 0, it means there is no relationship between the variables. If r is positive, it means that as one variable gets larger the other gets larger. If r is negative it means that as one gets larger, the other gets smaller (often called an "inverse" correlation).

RESULTS AND DISCUSSIONS

Fertility rates analysis of Mukota, Windsnyer and Kolbroek sows was indicated on Figure 1. Sow fertility remain one of the most fundamental trait in the breeding herd. Significant differences were obtained from the results where Mukota was observed to have the intermediate proportion of farrowing rate (68.75%) with the highest proportion (P<0.05) of the weaning rate (91.89%) and the lowest proportion of the weaning rate (21kg). Moreover, Windsnyer results obtained were significantly influenced (P<0.01) with the proportion of the lowest farrowing rate (56.25%) with proportion of the lowest weaning rate (79.17%) and proportion of the lowest weaning weight (18kg). However, Kolbroek was observed to have obtained results that had the highest proportion of the farrowing rate (87.5%) with the intermediate proportion of the weaning rate (88.57%) and the highest proportion of the weaning weight (27kg) of the three studied indigenous pig breeds.

Figure 2 chart provides the litter size graph of the three studied Southern African indigenous pig breeds; Mukota, Windsnyer and Kolbroek. These pigs provided evidence

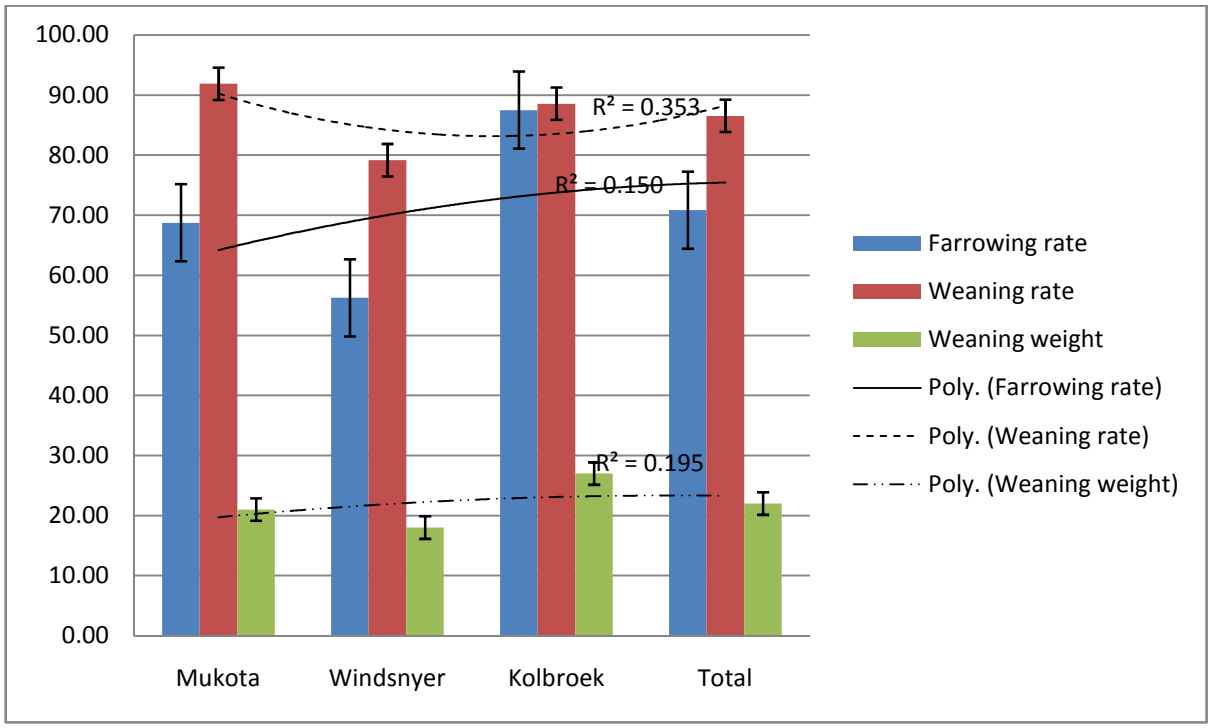

Figure 1. Fertility rates analysis of Mukota, Windsnyer and Kolbroek sows

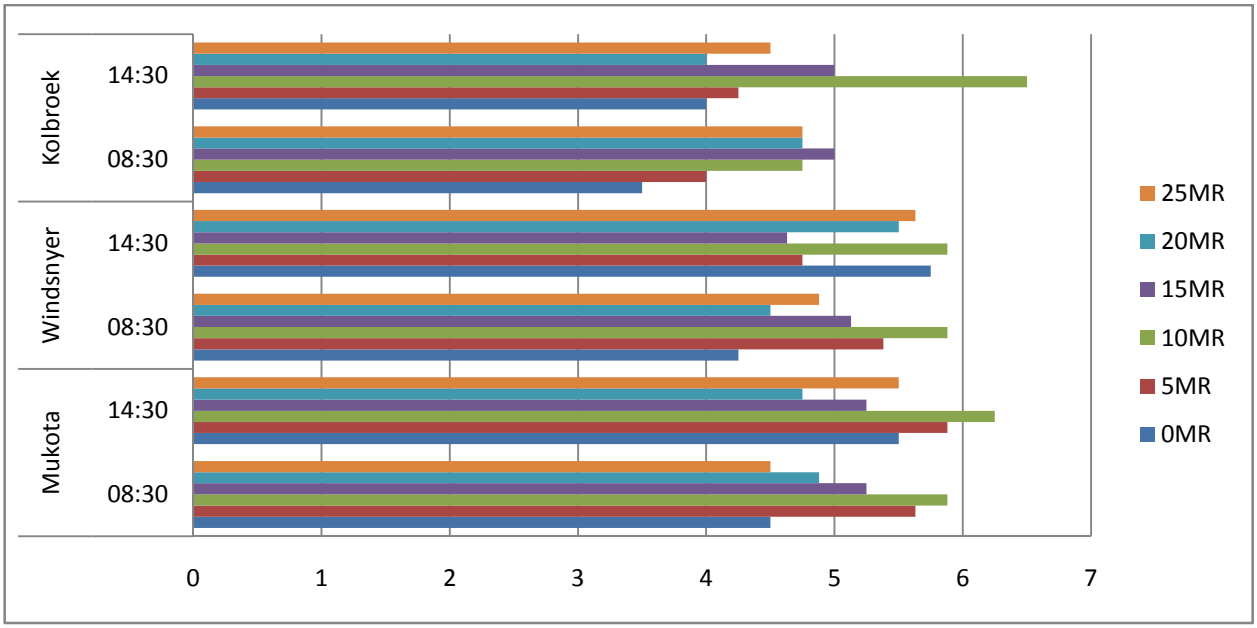

Figure 2. Litter size in Mukota, Windsnyer and Kolbroek sows

that with proper sexual preparation protocol (P<0.05), litter size and sow fertility can be improved. The highest litter size were obtained following 10MR in the afternoon from all studied breeds; Mukota 6.25, Windsnyer 5.88 and Kolbroek 6.5.

Correlations between libido of boar and fertility rates of Mukota, Windsnyer and Kolbroek sows

Mukota libido indicated to have positively responded to the sexual preparation and diurnal periods. Control group

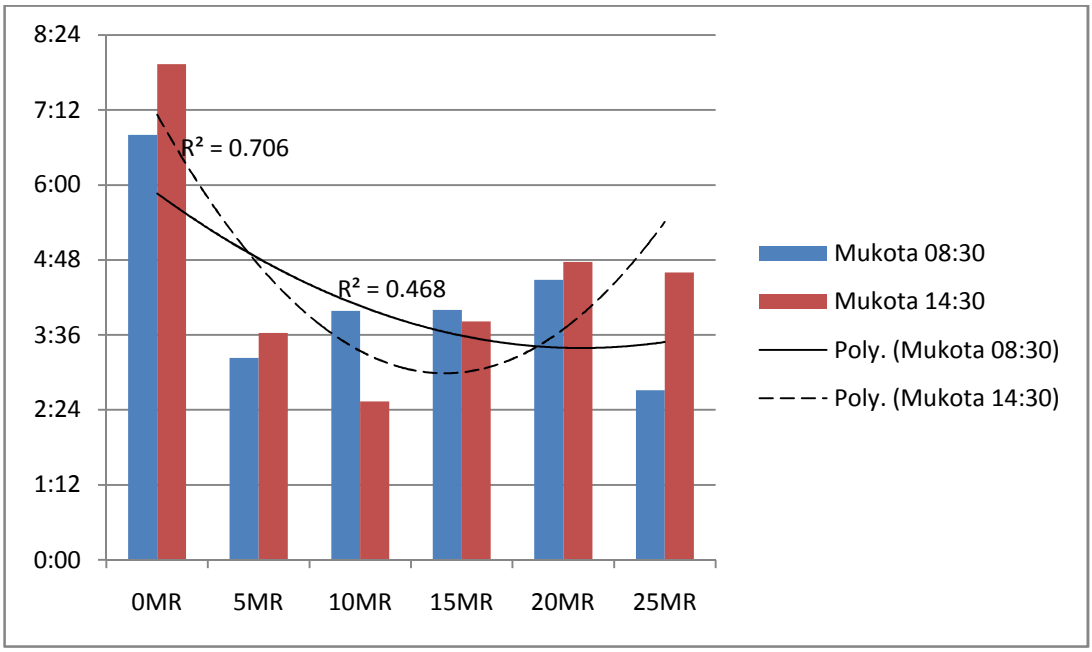

Figure 3. Libido in Mukota

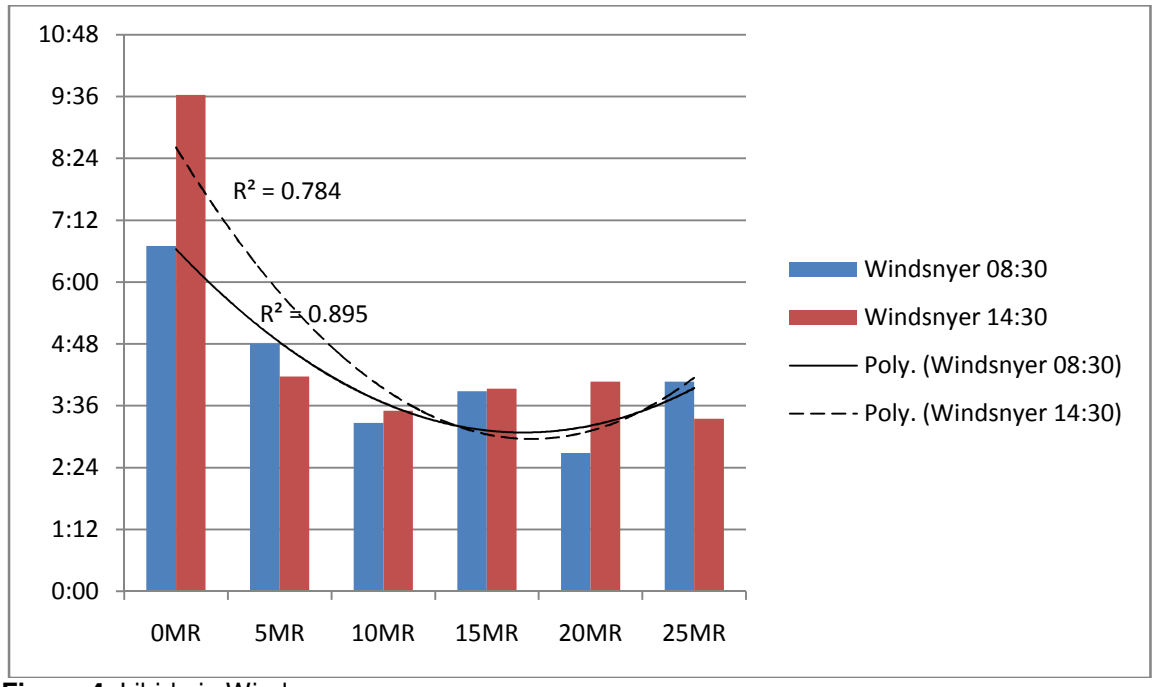

Figure 4. Libido in Windsnyer

when compared with the experimental groups, it became evident that libido was significantly influenced. Libido in Mukota significantly improved with reduced ($P<0.05$) reaction time during the afternoon and as compared control with the experiments following 10MR 02:32 in the afternoon (Figure 3).

There were significant differences in the reduction of reaction time and subsequent improvement of libido in Windsnyer obtained from the results (Figure 4). In comparison with the control group, the experimental groups' levels of sexual restraints and diurnal periods seemed to have had an influence on the results obtained

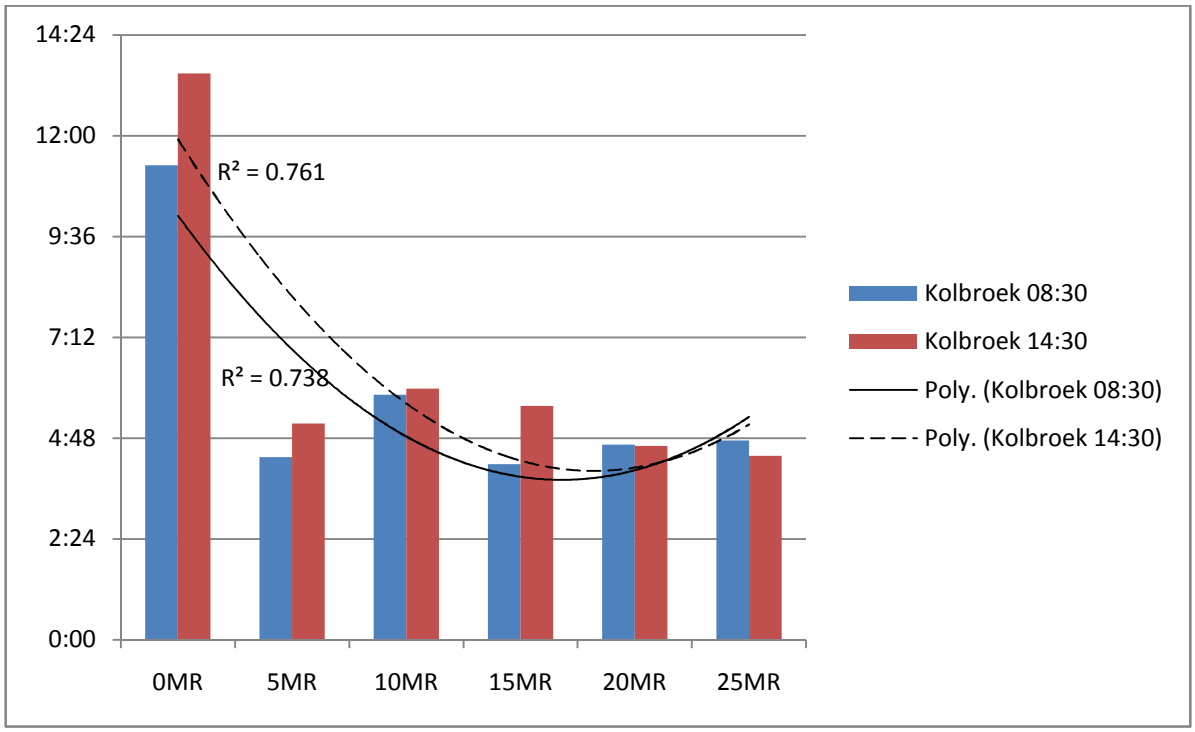

Figure 5. Libido in Kolbroek

Table 1. Correlation coefficient of libido and litter size in Southern African pig breeds

	0MR	5MR	10MR	15MR	20MR	25MR
0MR	-0.37168	-0.447	-0.77806	-0.45222	0.033469*	-0.33425
5MR		-0.63389	-0.87583	-0.59577	-0.20795	-0.37283
10MR			-0.32026	0.364937**	-0.01652	-0.16466
15MR				-0.12491	0.067893*	0.091764*
20MR					0.002506*	-0.49472
25MR						0.071525*

Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);*=(P<0.001)*

** Values are least square means ± standard error*

in Windsnyer boars. The lowest significant results (P<0.01) were obtained following 20MR 02:41, however, the intermediate significant results were obtained following 10MR 03:16 in the morning.

Results obtained of the libido of the Kolbroek boars were demonstrated on Figure 5. Compared to the control group, the experimental groups' libido improved with reduced reaction time. It is worth noting that the reaction time results obtained from Kolbroek boars breed indicated that Kolbroek take much longer or reaction time was recorded to be quite longer compared to other studied breeds. The polynomial was observed to be stronger during 14:30. The significantly lower reaction time results (P<0.05) were obtained following 15MR 04:11 in the morning. However, the strongest polynomial R^2=0.7617 was recorded during 14:30.

The proportions of the results obtained of the correlation coefficient of the libido and litter size in the Southern African indigenous pigs is represented in Table 1. The positive expression means that when the libido becomes larger the litter size becomes larger too. While the negative expression means that when the libido becomes larger the litter size becomes smaller. There were significant correlations observed amongst experimental groups. The highest significant (P<0.01) correlation were observed in libido following 10MR at a litter size of 15MR (r=0.364937) r^2= 15%.

The results obtained were observed to displaying

Table 2. Correlation coefficient of libido and semen volume in Southern African pig breeds

	0MR	5MR	10MR	15MR	20MR	25MR
0MR	0.737474***	0.65428***	0.343905**	0.396786**	0.073549*	0.479265**
5MR		0.259723**	-0.43947	-0.16334	-0.1211	0.542529**
10MR			0.031132	0.219669**	0.035378*	-0.87755
15MR				0.125434**	-0.19074	0.645278***
20MR					-0.36866	0.389109**
25MR						0.075594*

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)*

** Values are least square means ± standard error*

Table 3. Correlation coefficient of libido and motility in Southern African pig breeds

	0MR	5MR	10MR	15MR	20MR	25MR
0MR	-0.32558	-0.35304	-0.76636	0.071191*	-0.07451	0.013609*
5MR		-0.92888	-0.88964	0.084722*	0.005426*	-0.07531
10MR			-0.76467	-0.45582	-0.58202	0.474492**
15MR				-0.00159	0.001628*	-0.10688
20MR					0.047141*	-0.09326
25MR						-0.36612

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)*

** Values are least square means ± standard error*

proportions of correlation coefficient of the libido and semen volume in Southern African pig breeds was demonstrated in Table 2. The positive expression means that when the libido becomes larger the semen volume becomes larger too. While the negative expression means that when the libido becomes larger the semen volume becomes smaller. There were significant correlations (P<0.001) obtained amongst the control and experimental groups. Where libido and semen volume at control (r=0.737474) r^2= 35% was observed to correlate significantly higher compared to other expressions.

Table 3 represent the correlation coefficient of the libido and motility in Southern African indigenous pig breeds following sexual preparation techniques. There were correlations observed in the proportions of the results obtained from the control and experimental groups. Where significant correlations (P<0.05) were observed results provided a very small increase the proportions. However, significant correlation (P<0.01) was observed in the proportions at r=0.474492 (r^2=20%).

The libido and normal sperm correlation coefficient proportions in Southern African indigenous pig breeds were tabulated in Table 4. Significant correlations (P<0.001) were obtained in the normal sperm. The highest significant correlation was observed in the proportions from the results obtained at r=0.910487 (r^2= 45%). The intermediate significantly higher correlation was obtained at r=0.715366 (r^2=35%).

Southern African indigenous pig breeds libido and live sperm correlation coefficient was demonstrated in Table 5. The positive correlation expression refers to the phenomenal where when libido increases the live sperm count increases too. Meanwhile, the negative expression refers to an increase in libido leading to decrease in live sperm. There were significant correlations (P<0.001) obtained in the proportions observed in live sperm following 20MR. The highest significant correlation was observed at r=0.8288 (r^2=40%).

Correlations between semen viability traits of boar and fertility rates of Mukota, Windsnyer and Kolbroek sows

Table 5 outline the live sperm and litter size correlation coefficient of the Southern African indigenous pig breeds. Where there is a positive expression it indicates that when the proportions of the live sperm become larger, the proportions of litter size similarly become larger. Moreover, where there is a negative expression it

Table 4. Correlation coefficient of libido and normal sperm in Southern African pig breeds

	0MR	5MR	10MR	15MR	20MR	25MR
0MR	0.075366*	0.715968***	0.293427**	-0.26378	0.207522**	0.676125***
5MR		0.315308**	0.122807**	-0.30838	-0.17895	0.605659***
10MR			0.126944**	-0.66067	-0.26494	0.503341**
15MR				-0.10347	0.085956*	0.617668***
20MR					0.589748*	0.291554**
25MR						0.910487***

*Coefficient values for each trait with different superscript were different *=(P<0.05) ;**=(P<0.01);***=(P<0.001)*

** Values are least square means ± standard error*

Table 5. Correlation coefficient of libido and live sperm in Southern African pig breeds

	0MR	5MR	10MR	15MR	20MR	25MR
0MR	-0.3682	-0.04739	-0.41103	-0.01388	0.713887***	-0.59648
5MR		-0.1559	-0.6088	0.527729**	0.138441**	-0.42263
10MR			-0.40663	-0.03329	0.738897***	-0.54357
15MR				0.433612**	0.8288***	-0.40809
20MR					0.677623***	-0.37084
25MR						-0.9267

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)*

** Values are least square means ± standard error*

Table 6. Correlation coefficient of litter size and live sperm in Southern African pig breeds

	0MR	5MR	10MR	15MR	20MR	25MR
0MR	0.229451**	-0.01918	0.614641***	-0.02071	-0.33559	0.563008***
5MR		0.001205*	0.410347**	0.106933**	-0.48431	0.503132**
10MR			0.260263**	0.682909***	0.221394**	0.285451**
15MR				-0.0345	-0.05263	-0.18963
20MR					-0.41095	0.581916***
25MR						0.217222**

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)*

** Values are least square means ± standard error*

indicates that where proportions of live sperm become larger, the proportions of litter become lower. There were significant correlations (P<0.001) observed from proportions of the results obtained amongst experimental groups. The highest significant correlation was obtained at r=0.682909 (r^2=34%)

Litter size and normal sperm correlation coefficient in Southern African pig breeds was indicated in Table 6. The negative correlation indicates that when proportions of the normal sperm become larger, the proportions of litter size become lower. Nevertheless, the positive correlation indicates that when the proportions of normal sperm become larger, the proportions of litter size similarly become larger too. Significant correlations (P<0.001) were observed amongst experimental groups. Higher significant correlation was obtained at r=0.881019

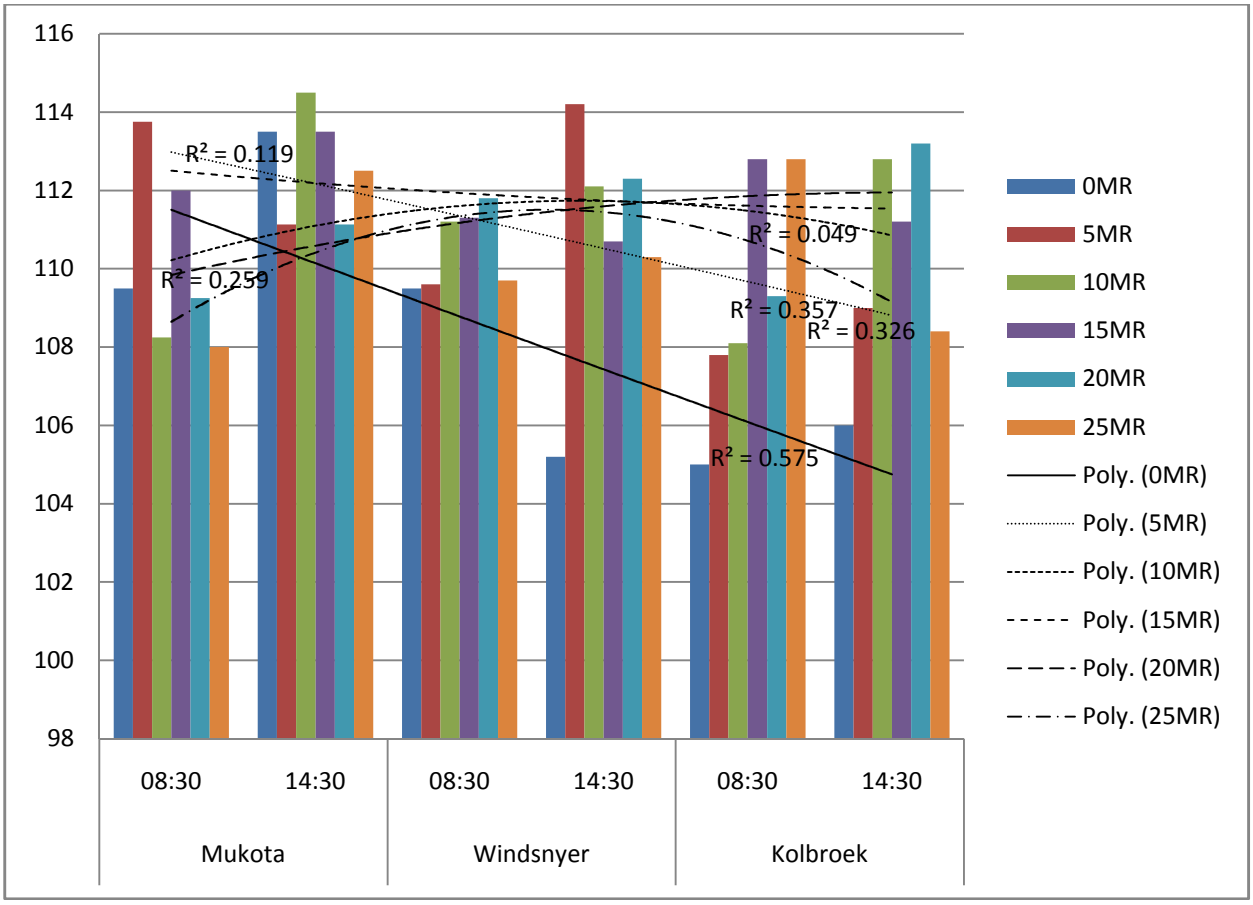

Figure 6. Semen concentrations per ejaculate in Mukota, Windsnyer and Kolbroek

(r^2=44%). When evaluating boar semen output for sow fertility rates, the ultimate goal is to accurately predict its fertilizing potential of the semen specimen produced. Even much advancement achieved in semen quality and assisted reproductive techniques, the ability to predict the fertility of semen with laboratory tests remain limited, mainly due to the complexity of the spermatozoon and the fertilization process. The most reliable approach to predict the potential fertility of semen is to use a combination of tests to evaluate different sperm attributes, thereby increasing the accuracy of the estimate. Semen volume, semen concentration, motility, live and normal sperm are essential for proper function of the spermatozoa post ejaculation to carry out functions such as sperm metabolism, capacitation, ova binding and acrosome reaction. Tests to evaluate sperm characteristics include permeability to stains and biochemical function was considered where sperm stains such as eosin/nigrosin (EN) and trypan-blue (TB) were used.

The results obtained of the semen concentration per ejaculate responses from various levels of sexual preparations are displayed on Figure 6. There were significant increases ($P<0.05$) in proportions of semen concentration per ejaculate in Mukota, Windsnyer and Kolbroek following 10MR 111.5 ($x10^9$), 5MR 114.2 ($x10^9$) and 20MR 113.2 ($x10^9$). The lowest polynomial was obtained following 10MR (R^2=0.0494).

The semen concentration per ejaculate correlation coefficient amongst Southern African indigenous pig breeds was illustrated on Table 7. There was significant correlation ($P<0.001$) obtained from the semen concentration per ejaculate results observed amongst experimental groups. A proportion of a significantly higher correlation was obtained from the results at r=0.758453 (r^2=35%).

A semen concentration per millilitre graph is illustrated in Figure 7 for the Mukota, Windsnyer and Kolbroek pig breeds. The proportion of semen concentration per mL results obtained were reported significant differences ($P<0.05$) with high following 10MR 08:30 and 15MR 14:30 at 755 ($x10^6$). The proportions of semen concentration per mL results obtained from Windsnyer and Kolbroek yielded significant differences following

Table 7. Correlation coefficient of litter size and normal sperm in Southern African pig breeds

	0MR	5MR	10MR	15MR	20MR	25MR
0MR	0.066562*	0.330547**	0.217569**	0.881019***	0.529114**	-0.45238
5MR		-0.54915	0.051152*	0.607092***	0.216067**	-0.45901
10MR			0.828069***	0.81542***	0.448564**	0.067283*
15MR				-0.04851	0.090856*	0.141854**
20MR					-0.02787	-0.73998
25MR						-0.19976

Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);*=(P<0.001)*

** Values are least square means ± standard error*

Table 8. Correlation coefficient of semen concentration per ejaculate in Southern African pig breeds

Semen con per eja.	5MR	10MR	15MR	20MR	25MR
0MR	0.171339**	0.407725**	0.569302***	-0.14024	0.120854**
5MR		0.056969*	-0.2874	-0.03003	-0.3578
10MR			-6.1E-05	0.758453***	0.126292**
15MR				-0.59381	0.673358***
20MR					-0.28199

Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);*=(P<0.001)*

** Values are least square means ± standard error*

15MR 724 ($x10^6$) and 20MR 734 ($x10^6$) in the morning respectively.

Semen concentration per millilitre correlation coefficient in Southern African indigenous pigs was obtained from Table 8. There were proportions of significant correlations (P<0.001) obtained from the results observed amongst experimental groups. The higher significant correlations were obtained from the proportions observed at r=0.657916 (r^2=32%).

The proportions of semen volume of Mukota, Windsnyer and Kolbroekwere demonstrated on Figure 8. Significant differences (P<0.05) of proportions amongst the studied breeds, between treatments and diurnal periods were obtained with semen volume. There were significant higher increases obtained in the results with Mukota, Windsnyer and Kolbroek following 15MR 14:30 (116.3 mL, 115.72 mL) and 10MR 08:30 (115.64 mL) respectively.

The correlation coefficient of semen volume in Southern African indigenous pigs was demonstrated in Table 9. The proportions observed from the experimental groups resulted into significant correlations (P<0.001). The very high proportions of significant correlation obtained was observed at r=0.929747 (r^2=46%).

The proportions of motility rate following various minutes of sexual restraints and diurnal periods were demonstrated in Figure 9. There were significant difference (P<0.05) obtained in the results amongst experimental groups, treatments and diurnal periods. There were significantly higher proportions of motility observed in MUkota, Windsney and Kolbroek following 15MR 14:30 (88.2%), 10MR 14:30 (80.2%) and 20MR 08:30 (78.4%) respectively. However, proportion of intermediate significant (P<0.05) results obtained in Kolbroek was recorded following 15MR 14:30 (78.3%).

The motility correlation coefficient of the Southern African indigenous pig breeds were demonstrated in Table 10. The proportions of significant correlations were observed from the results obtained amongst experimental groups. Higher proportions of significant correlation was obtained from the results observed at r=0.815312 (r^2=40%).

Live sperm was considered all the functional sperms that showed life on the specimen under microscope during the analysis of the semen. Figure 10 demonstrate the live sperm in Mukota, Windsnyer and Kolbroek. Significant differences (P<0.05) were obtained amongst experimental groups, treatments and diurnal periods. Proportions of higher live sperms were obtained in experimental groups following 5MR 08:30 (78%), 25MR 14:30 (78%) with intermediate proportion of 10MR 14:30 (76%) and 20MR 14:30 (78%) with intermediate

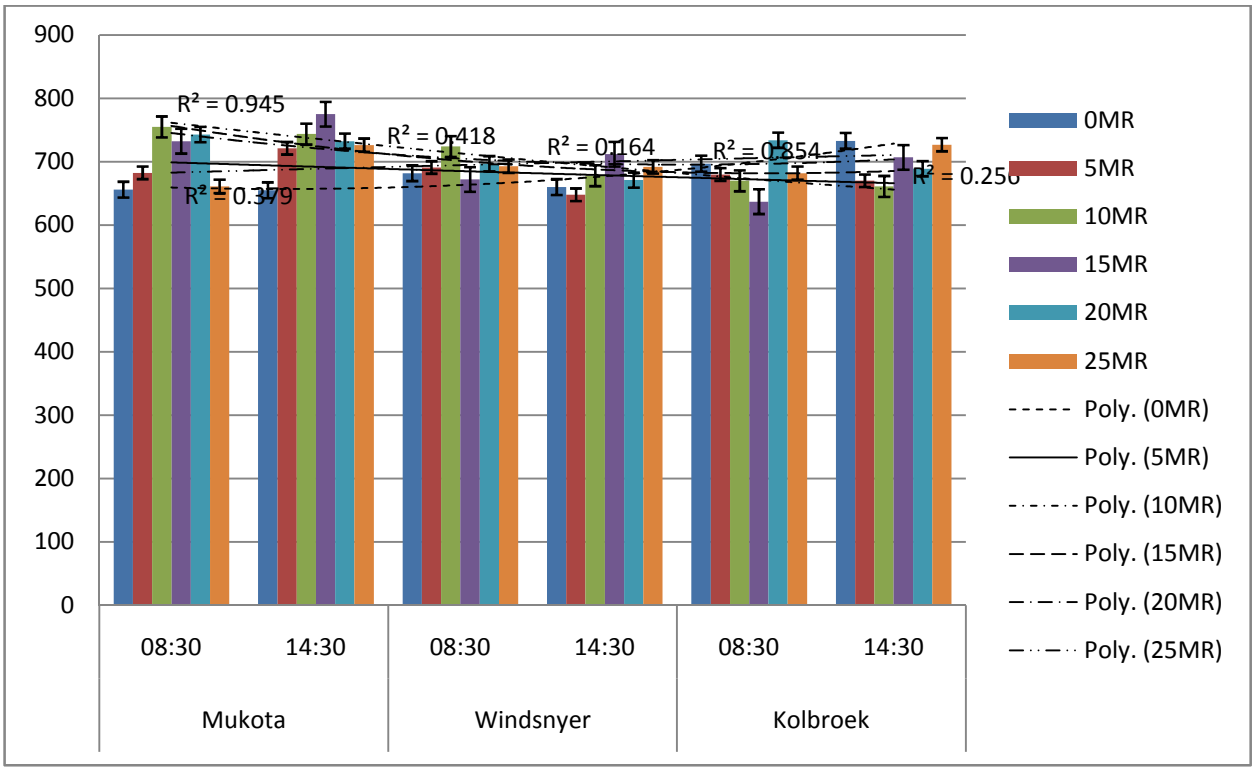

Figure 7. Semen concentrations per millilitre in Mukota, Windsnyer and Kolbroek

Table 9. Correlation coefficient of semen concentration per millilitre in Southern African pig breeds

Semen con per ml	5MR	10MR	15MR	20MR	25MR
0MR	-0.26036	-0.72545	-0.50075	-0.29124	0.394551**
5MR		0.657916***	0.404452**	0.652145***	0.300689**
10MR			0.57301***	0.572768***	-0.26637
15MR				0.13688**	0.365253**
20MR					-0.33578

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)*

** Values are least square means ± standard error*

proportion of 5MR 14:30 (74%) respectively. There was a very strong polynomial R^2-0.9315 at 20MR.

Table 11 indicate the correlation coefficient of the live sperm in the Southern African indigenous pig breeds. Significant correlations (P<0.001) of the proportions of the obtained results were observed. The highest proportions of the significant correlation obtained was observed at r=0.910148 (r^2=45%).

Normal sperm proportions were analysed and evaluated of Mukota, Windsnyerand Kolbroek and shown on Figure 11. There were significant variations P<0.05 amongst experimental groups, between treatments and diurnal periods obtained. Results obtained were observed to show proportion of normal sperm significant differences in Mukota following 20MR 14:30 (77%) with intermediate proportion of 15MR 14:30 (73%), in Windsnyer following 5MR 14:30 (75%) and in Kolbroek 10MR 14:30 (78%). The intermediate polynomial R^2=0.4685 was observed following 5MR.

The Table 12 outline the correlation coefficient of the normal sperm of the Southern African indigenous pig breeds. The proportions of the significant correlations were obtained from the results observed amongst experimental groups. Significantly higher proportions

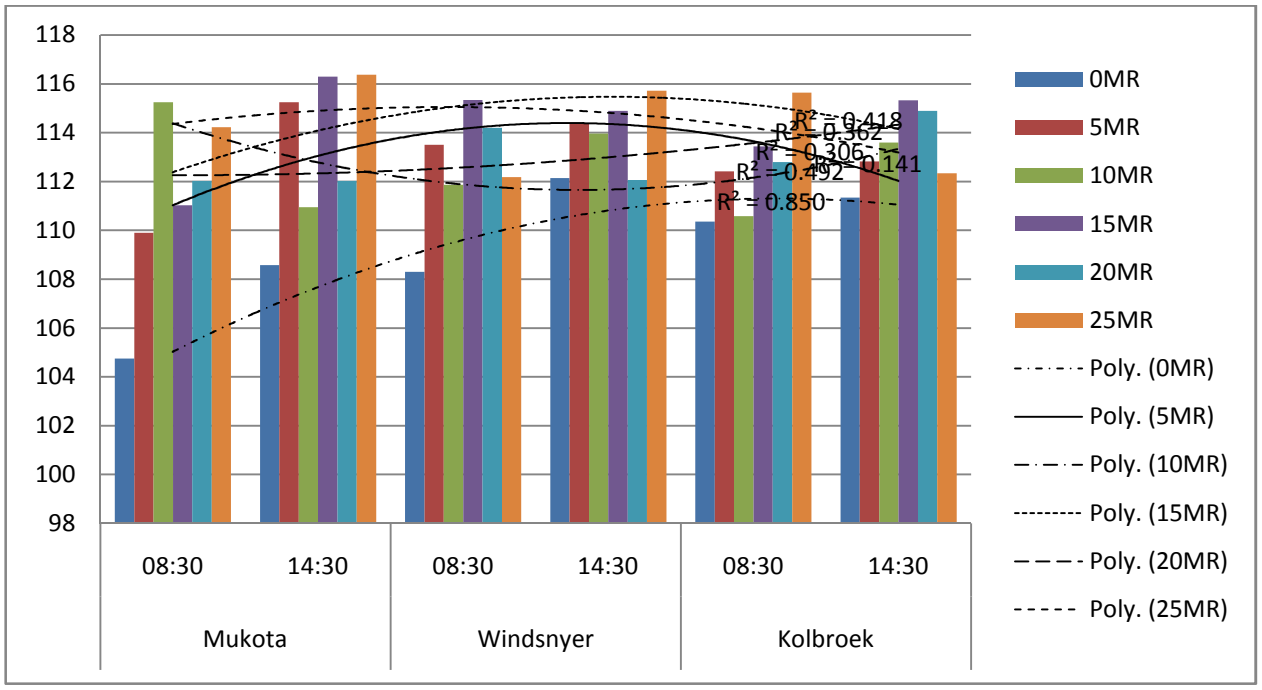

Figure 8. Semen volumes in Mukota, Windsnyer and Kolbroek

Table 10. Correlation coefficient of semen volume in Southern African pig breeds

Semen volume	5MR	10MR	15MR	20MR	25MR
0MR	0.602909***	-0.25647	0.607072***	0.293648**	0.100785**
5MR		-0.55296	0.929747***	-0.00696	0.317104**
10MR			-0.52622	-0.07186	-0.28928
15MR				0.339669**	-0.01031
20MR					-0.86543

Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);*=(P<0.001)*

** Values are least square means ± standard error*

Table 11. Correlation coefficient of motility in Southern African pig breeds

Motility	5MR	10MR	15MR	20MR	25MR
0MR	0.54436**	0.408695**	0.589824***	0.633705***	-0.70384
5MR		0.815312***	-0.0143	0.098228*	-0.00429
10MR			0.014334*	0.173316**	-0.02112
15MR				0.937608***	-0.94504
20MR					-0.9676

Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);*=(P<0.001)*

** Values are least square means ± standard error*

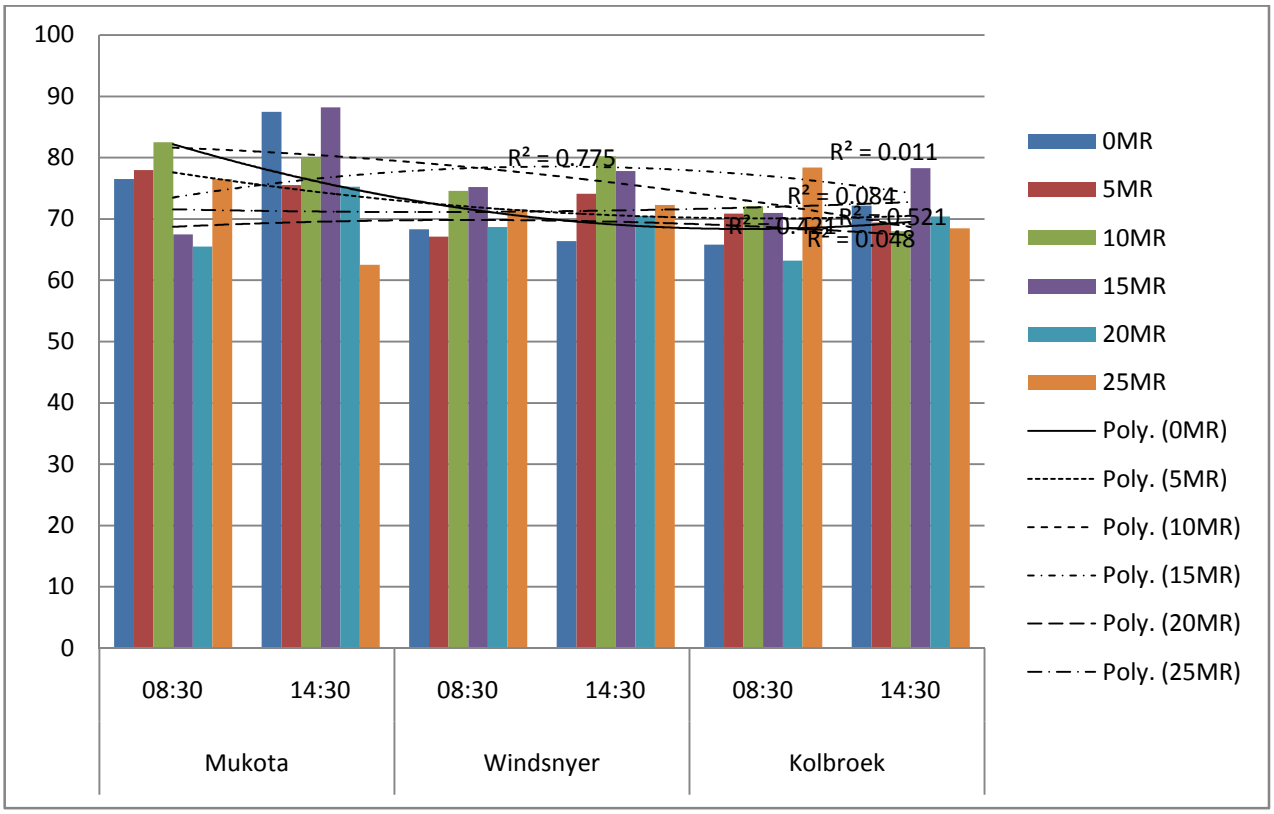

Figure 9. Motility in Mukota, Windsnyer and Kolbroek

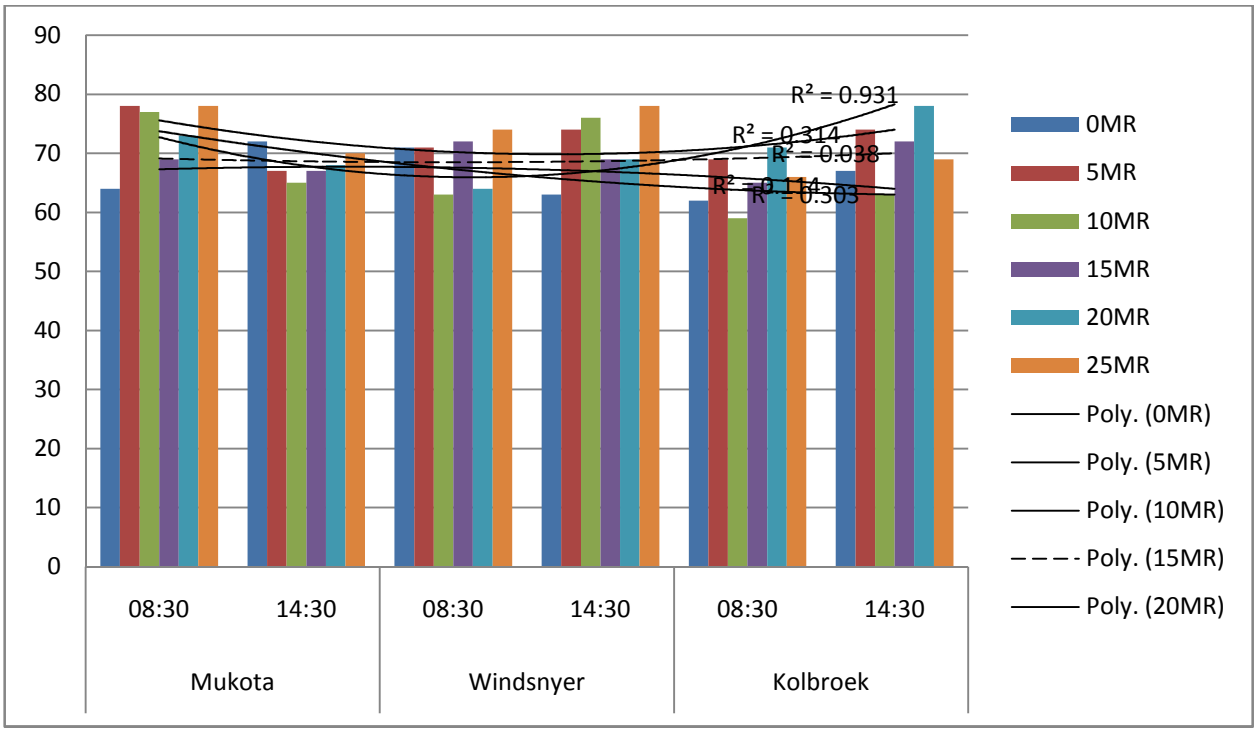

Figure 10. Live sperm in Mukota, Windsnyer and Kolbroek

Table 12. Correlation coefficient of live sperm in Southern African pig breeds

Live sperm	5MR	10MR	15MR	20MR	25MR
0MR	-0.47025	-0.32484	0.377241**	-0.42168	-0.1189
5MR		0.724726***	0.456765**	0.470443**	0.684093***
10MR			0.116162**	0.04761*	0.910148***
15MR				0.091361*	0.364934**
20MR					-0.23227

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)
* Values are least square means ± standard error

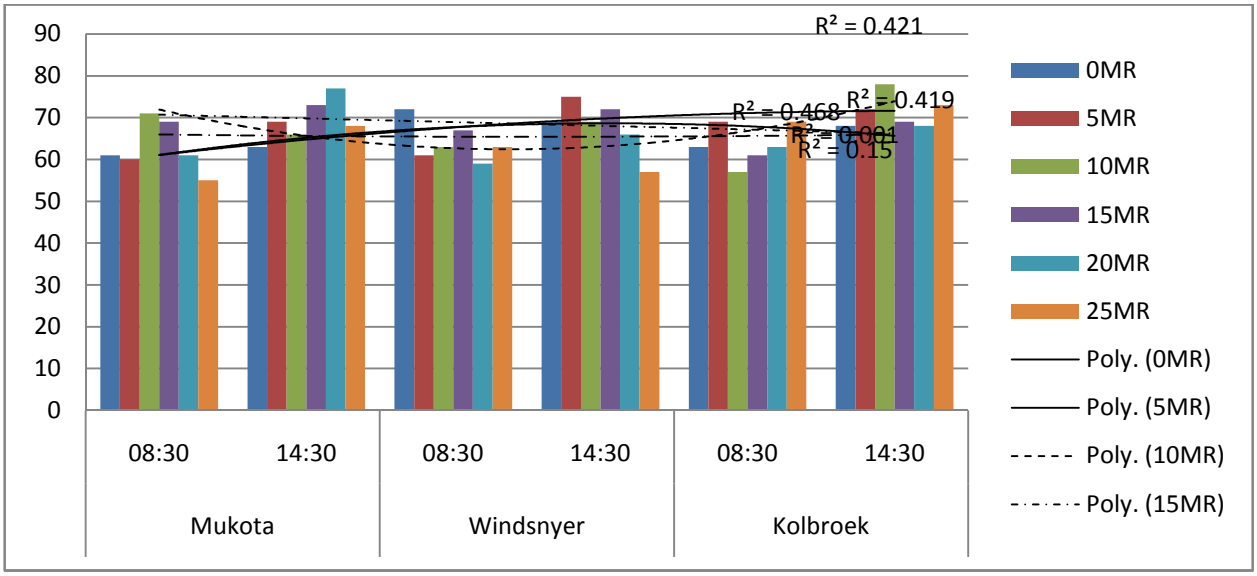

Figure 11. Normal sperm in Mukota, Windsnyer and Kolbroek

Table 13. Correlation coefficient of normal sperm in Southern African pig breeds

Normal sperm	5MR	10MR	15MR	20MR	25MR
0MR	0.163491**	0.110486**	0.098093*	-0.2679	0.059011*
5MR		0.203269**	0.234196**	0.541076**	0.353785**
10MR			0.593038***	0.215022**	-0.00523
15MR				0.588085***	-0.27942
20MR					0.433854**

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)
* Values are least square means ± standard error

were obtained from the results observed at r=0.593038 (r^2=25%).

Correlations between acrosomal morphology of boars and fertility rates of Mukota, Windsnyer and Kolbroek sows

The least square means (± s.e.) for boars missing apical ridge (MAR) test following six levels of sexual restraint and two diurnal periods was illustrated in Table 13. There were fragments of significant differences P<0.01 of proportion of MAR obtained from the results amongst experimental groups. Significant proportions of higher results were obtained following 5MR 14:30 (1.5±0.55), 15MR 08:30 (1.6±0.48) and 15MR 14:30 (3.8±0.59) and 5MR 14:30 (2.1±1.09) and 15MR 14:30 (2.9±1.12) in

Table 14. The least square means (± s.e.) for boars missing apical ridge (MAR) test following six levels of sexual restraint and two diurnal periods

MAR	Mukota		Windsnyer		Kolbroek	
	08:30	14:30	08:30	14:30	08:30	14:30
0	8.5±1.87	5.5±1.55^{c}	2.7±1.22	4.9±0.82^{a}	4.7±1.70	6.1±2.17
5	7.2±2.15^{a}	1.5±0.55^{e*}	12.2±4.22^{d}	7.3±1.99^{b}	12.5±2.86e	2.1±1.09^{e*}
10	6.5±1.91^{b}	10.5±5.34^{c}	11.1±3.37^{d}	5.8±1.21^{c}	4.3±1.71^{a}	9.3±1.94^{d}
15	6.7±1.45^{b}	9±2.33^{c}	1.6±0.48^{e*}	3.8±0.59^{d*}	7.4±0.73^{b}	2.9±1.12^{e*}
20	8.6±1.36	11±3.86^{d}	11.8±2.04^{d}	9.4±1.90^{a}	9.3±1.95^{c}	6.1±1.93
25	11.3±2.68^{d}	9.1±1.81^{c}	6.9±1.04^{c}	9.5±2.87^{a}	9.7±1.98^{c}	8.2±3.48^{d}

^{a,b,c,d,e} *Mean values for each trait with different superscript letters, were different (P<0.05) ; *=(P<0.01);**=(P<0.001)*

** Values are least square means ± standard error*

Table 15. The least square means (± s.e.) for boars loose acrosomal cap (LAC) test following six levels of sexual restraint and two diurnal periods

LAC	Mukota		Windsnyer		Kolbroek	
	08:30	14:30	08:30	14:30	08:30	14:30
0	8.3±2.17	10.9±4.26	12.6±1.96	4.1±1.52^{a**}	8.3±1.50	5.6±1.59^{d}
5	13.9±2.35	15.6±2.57	10.2±1.21^{a}	13.7±1.35^{b}	8.1±1.51	12.4±2.33^{b}
10	12.5±2.84	10.5±2.58^{a}	13.6±1.84	14.5±3.42	6.5±2.65	9.3±1.30^{c}
15	10.6±4.25	12.8±3.59	10.6±3.26^{a}	6.3±2.70^{c}	10.7±1.54	4.4±1.48^{d*}
20	10.8±2.33	11.6±1.40	11.1±2.38^{a}	14.6±1.88^{d}	7.5±2.65^{a}	9.2±1.73
25	11.3±2.21	9.1±2.61^{a}	6.4±1.82^{c}	9.3±2.95	10.9±2.67	13.2±0.88

^{a,b,c,d,e} *Mean values for each trait with different superscript letters, were different (P<0.05) ; *=(P<0.01);**=(P<0.001)*

** Values are least square means ± standard error*

Mukota, Windsnyer and Kolbroek respectively.

Table 14 shows the least square means (± s.e.) for boars loose acrosomal cap (LAC) test following six levels of sexual restraint and two diurnal periods. High proportions of reduced loose acrosomal cap results are favourable for more productive and viable sperm output. There was no significant improvement in LAC between treatments and amongst experimental groups. However, there were proportions of negative significant (P<0.05) influences obtained in all treatments. The proportions of significantly reduced were obtained from results with significantly higher proportions following 15MR 14:30 (4.4±1.48) amongst experimental groups.

The least square means (± s.e.) for boars damage apical ridge (DAR) test following six levels of sexual restraint and two diurnal periods is determined in Table 15. DAR was significantly reduced with proportions of significant differences P<0.05 between treatments amongst experimental groups in all studied breeds. The significantly reduced proportions of DAR were obtained with the significantly high reduction following 10MR 08:30 (9±2.16), 5MR 08:30 (7±1.15) and 10MR 08:30 (6±1.41).

Table 16 illustrate the least square means (± s.e.) for boars normal apical ridge (NAR) test following six levels of sexual restraint and two diurnal periods. Significant P<0.01 proportions of increase in NAR was observed from the results obtained between treatments in experimental groups of all studied breeds. There was a higher significant difference in proportion of NAR obtained between treatments in Mukota, Windsnyer and Kolbroek following 15MR 14:30 (76±2.94), 20MR 14:30 (74.6±2.58) and 15MR 08:30 (70.7±3.89) respectively.

The comparison analysis was expressed amongst Southern African indigenous breeds in Figure 5.12. Reduced MAR favours fertility as less abnormal spermatozoa result in high semen viability. As indicated (Fig. 5.12) there were significant differences (P<0.01) amongst experimental groups, diurnal periods and between treatments. The very low proportion of significant results obtained in Mukota following 5MR

Table 16. The least square means (± s.e.) for boars damage apical ridge (DAR) test following six levels of sexual restraint and two diurnal periods

DAR	Mukota		Windsnyer		Kolbroek	
	08:30	14:30	08:30	14:30	08:30	14:30
0	22±9.93	28±5.83	21±4.69	8±2.16^{a*}	38±424	18±3.27^{a}
5	12±2.94^{c}	18±3.74^{a}	7±1.15^{c*}	12±3.83^{b}	15±1.83^{b}	21±8.41^{b}
10	9±2.16^{d*}	33±4.24	16±4.40^{b}	14±2.94^{a}	6±1.41^{c*}	24±1.41
15	18±8.76^{a}	14±4.55^{a}	26±7.12	18±8.98	17±7.35^{a}	19±6.48
20	16±3.65^{b}	12±3.92^{b}	16±3.56^{b}	12±1.83^{c}	9±3.92^{b*}	16±2.16^{c}
25	13±3.27^{c}	19±6.78^{a}	19±2.16^{a}	13±1.41^{b}	7±1.83^{c*}	18±2.93^{d}

^{a,b,c,d,e} *Mean values for each trait with different superscript letters, were different (P<0.05) ; *=(P<0.01);**=(P<0.001)*

** Values are least square means ± standard error*

Table 17. The least square means (± s.e.) for boars normal apical ridge (NAR) test following six levels of sexual restraint and two diurnal periods

NAR	Mukota		Windsnyer		Kolbroek	
	08:30	14:30	08:30	14:30	08:30	14:30
0	53.1±6.59	62.6±5.03^{a}	60.9±2.64	66±8.12	58.3±2.12	56.6±7.57
5	59±3.46^{a}	66±4.32^{b}	57.7±3.89	69±6.83^{a}	58.1±3.73	62.4±8.07^{b}
10	68.6±5.17^{b*}	71.1±1.33c*	63.9±5.95^{a}	67.9±2.74^{a}	60.5±6.56^{a}	59.3±4.32^{a}
15	62.9±4.05^{b}	76±2.94^{c*}	60.6±3.14	68.3±2.15^{a}	70.7±3.89^{c*}	64.4±2.03^{b}
20	57±5.48^{a}	61.1±7.06	72.3±2.27^{b*}	74.6±2.58^{b*}	57.5±3.87	59.2±2.26^{a}
25	51.8±6.00^{a}	66±6.98^{d}	64.2±6.99^{a}	69.3±2.77^{a}	60.9±0.84^{b}	53.2±3.64^{a}

^{a,b,c,d,e} *Mean values for each trait with different superscript letters, were different (P<0.05) ; *=(P<0.01);**=(P<0.001)*

** Values are least square means ± standard error*

14:30 (1.5%), in Windsnyer following 15MR 08:30 (1.6%). It is interesting to note the sharp increase in proportions of MAR following 20MR and 25MR with all experimental groups. However, the lowest polynomial was observed in Windsnyer 08:30 (R^2=0.0903).

The correlation coefficient of the missing apical ridge in the Southern African pig breeds was tabulated in Table 17. The significant correlation (P<0.001) was obtained from the proportions of the results obtained from the experimental groups. The proportions of the higher significant correlation obtained from the results was observed at r=0.814509 (r^2=40%).

The proportions of damage apical ridge rates in indigenous boars' breeds of Southern Africa were indicated in Figure 13. There were significant differences P<0.05 amongst experimental groups and diurnal periods on obtained results. Obtained results revealed significant differences in the proportions of the DAR following 5MR 14:30 (7%) and 10MR 08:30 (6%). The very low polynomial was obtained in Windsnyer 08:30 (R^2=0.0565).

The Table 18 display the damage apical ridge correlation coefficient of the Southern African indigenous pig breeds. The negative significant correlation means that when proportions of damage apical ridge increases at a given level; the proportions of damage apical at another given level decreases. There were proportions of the significant correlation (P<0.01) obtained from the results of the observed experimental groups. The higher proportions of the significant correlations were observed from the results obtained at r=0.804136 (r^2=40%). However there was a higher significant negative correlation obtained from the proportions of the results observed at r=-0.66627 (r^2=30%).

Illustration of the proportions of the loose acrosomal cap in the Southern African indigenous pig breeds is demonstrated in Figure 14. The significant differences (P<0.05) were obtained in the results observed amongst

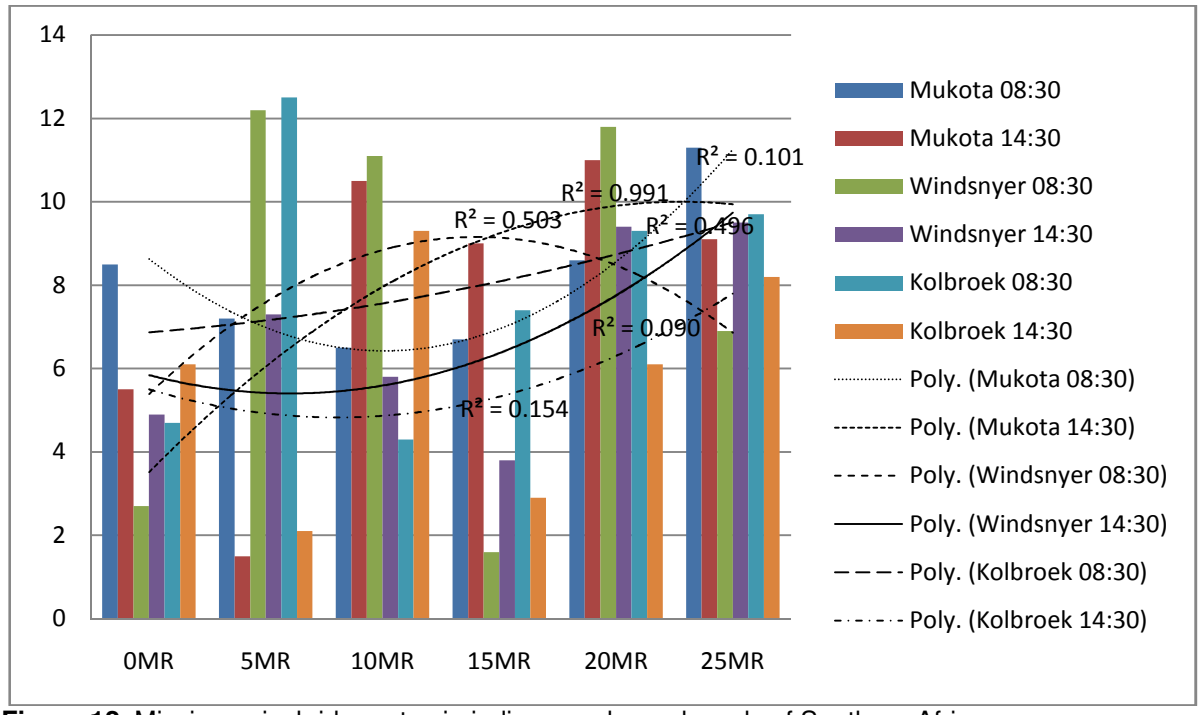

Figure 12. Missing apical ridge rates in indigenous boars breeds of Southern Africa.

Table 18. Correlation coefficient of missing apical ridge in Southern African pig breeds

MAR	5MR	10MR	15MR	20MR	25MR
0MR	-0.47568	-0.31001	0.447039**	-0.58175	0.814509***
5MR		-0.38622	-0.24029	0.407239**	-0.09083
10MR			-0.29878	0.315672**	-0.70051
15MR				0.125646**	0.655346***
20MR					-0.27914

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)*
** Values are least square means ± standard error*

Table 19. Correlation coefficient of damage apical ridge in Southern African pig breeds

DAR	5MR	10MR	15MR	20MR	25MR
0MR	0.18698**	-0.12955	-0.28776	-0.48988	-0.38389
5MR		0.528601**	-0.66627	-0.171	0.077864*
10MR			-0.38207	0.169516**	0.804136***
15MR				0.542228**	0.180806**
20MR					0.649453***

*Coefficient values for each trait with different superscript were different *=(P<0.05) ; **=(P<0.01);***=(P<0.001)*
** Values are least square means ± standard error*

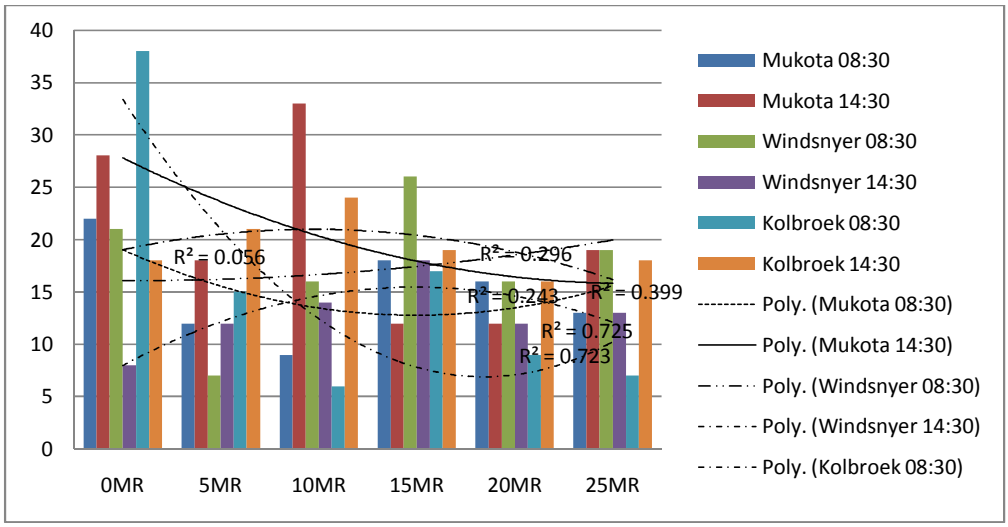

Figure 13. Damage apical ridge rates in indigenous boars breeds of Southern Africa.

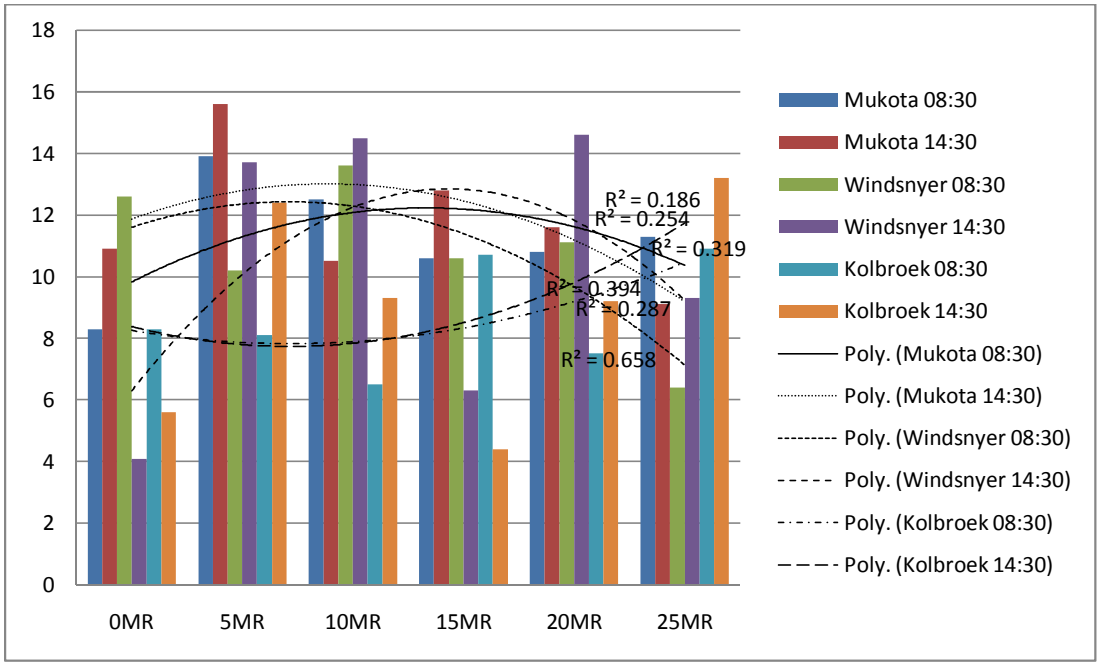

Figure 14 Loose acrosomal cap rates in indigenous boars breeds of Southern Africa.

treatments, experimental groups and diurnal periods. The proportions of the more reduced LAC were obtained following 10MR 08:30 (6.5%), 15MR 14:30 (4.4%) and 25MR 08:30 (6.4%) respectively. The strongest polynomial was obtained in Windsnyer 08:30 (R^2=06582), the intermediate in Kolbroek 08:30 (R^2=0.394) and low in Mukota 14:30 (R^2=0.3192).

The correlation coefficient of the loose acrosomal cap in the Southern African indigenous pigs was indicated in Table 19. The proportions of the significant correlations (P<0.001) were obtained from the results observed from the experimental groups. The results were obtained and the proportions were observed to be higher at r=0.875512 (r^2=40%). However, the higher negative significant correlation was obtained at r=-0.63906 (r^2=30%).

The normal apical ridge rate in Southern African indigenous pigs' boars was shown in Figure 15. Significant differences were observed in the result obtained from the proportions of the NAR amongst experimental groups, treatments and diurnal periods. The proportion of NAR from the obtained results produced significant differences following 10MR 14:30 (71.1%),

Table 20. Correlation coefficient of loose acrosomal cap in Southern African pig breeds

LAC	5MR	10MR	15MR	20MR	25MR
0MR	-0.15221	-0.00487	0.804347***	-0.21823	-0.63906
5MR		0.462904**	0.007734*	0.642203***	0.070016*
10MR			-0.1018	0.875512***	-0.5461
15MR				-0.13116	-0.49926
20MR					-0.45152

*Coefficient values for each trait with different superscript were different
*=(P<0.05) ; **=(P<0.01);***=(P<0.001)
* Values are least square means ± standard error

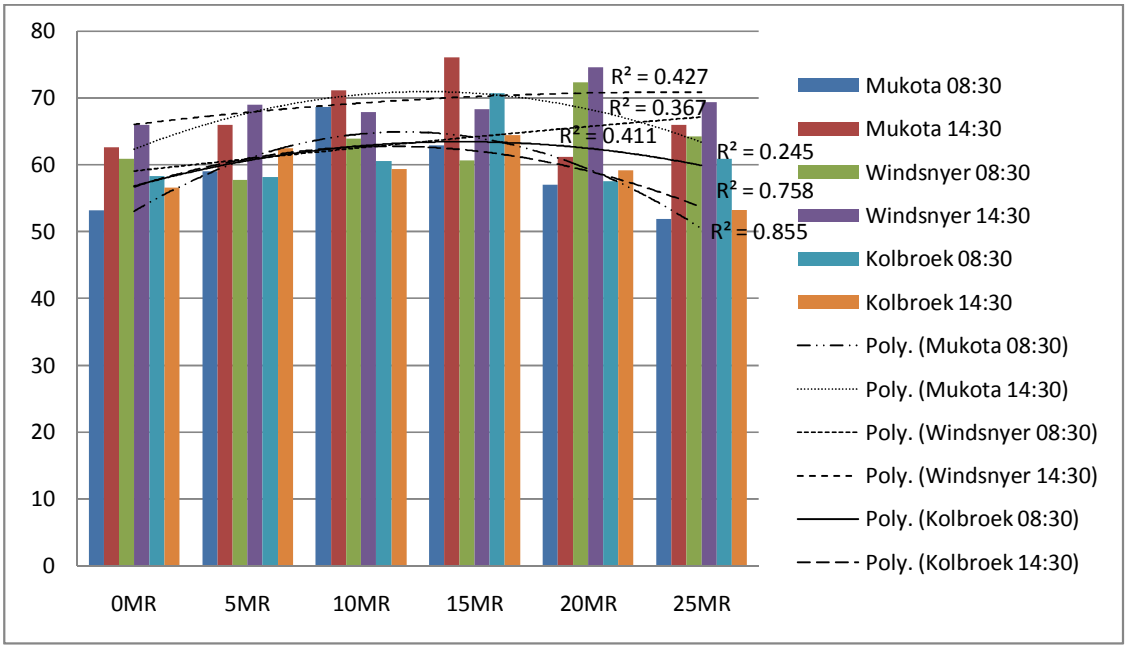

Figure 15. Normal apical ridge rates in indigenous boars breeds of Southern Africa

Table 21. Correlation coefficient of normal apical ridge in Southern African pig breeds

NAR	5MR	10MR	15MR	20MR	25MR
0MR	0.702236***	0.323041**	0.436905**	0.776474***	0.96312***
5MR		0.489478**	0.52718**	0.395014**	0.543884**
10MR			0.364193**	0.194252**	0.376232**
15MR				-0.21729	0.464436**
20MR				0.735594***	

*Coefficient values for each trait with different superscript were different
*=(P<0.05) ; **=(P<0.01);***=(P<0.001)
* Values are least square means ± standard error

The normal apical ridge correlation coefficient of the Southern African indigenous pig breeds was represented in Table 20. Significant correlation (P<0.001) was observed in the proportions of the results obtained from the experimental groups. The highest proportions of significant correlation was obtained from the results and observed at r=0.96312 (r^2=45%).

CONCLUSION

There was significant influence observed to libido, semen volume, motility and semen concentration between treatments and diurnal periods, libido improved in Mukota, semen volume was increased in Windsnyer and Kolbroek, motility was increased in Windsnyer, semen concentration per mL decreased while semen concentration per ejaculate increased in all studied breeds. Normal sperm improved significantly in Windsnyer and Kolbroek and live sperm was observed to have increased in Windsnyer and Kolbroek but both normal and live sperm decreased in Mukota in the afternoon. Libido was significantly improved in all breeds, semen volume was significantly improved, with increases recorded in Mukota and Kolbroek in the afternoon, motility was increased in all studied breeds at this level of sexual restraint. Semen concentration per mL was recorded to have increased in all studied breeds while semen concentration per ejaculate was observed to have increased in Mukota and decreased in Windsnyer and Kolbroek. Normal sperm was increased in all studied breeds and was significantly increased in Mukota and Kolbroek. Live sperm decreased in Mukota and Windsnyer but significantly increased in Kolbroek and significant increases in live and normal sperm were recorded in all studied breeds between treatments and diurnal periods.

Libido, semen volume and semen concentration were not significantly influenced by 20MR in the afternoon, libido was only reduced in Kolbroek of three studied breeds, semen volume only increased in Kolbroek following 20MR;14:30. Motility increased in all studied breeds and was observed to have significantly improved in Mukota. Semen concentration per mL decreased while semen concentration per ejaculate increased in all studied breeds. Normal sperm increased in all studied breeds and significantly increased in Mukota and Windsnyer, while live sperm significantly increased in Windsnyer and Kolbroek and decreased in Mukota. Libido, semen volume and semen concentration were not significantly influenced by 25 MR during the afternoon, libido decreased in Windsnyer and Kolbroek, semen volume increased in Mukota and Windsnyer, motility was significantly increased in Mukota and increased in Windsnyer but significantly decreased in Kolbroek. Semen concentration per mL recorded to have increased in Mukota and Kolbroek while in semen concentration per ejaculate increased in Mukota and Windsnyer. Normal sperm increased in Mukota and significantly increased in Kolbroek while live sperm increased in Windsnyer and significantly increased in Kolbroek.

Libido and semen volume were not significantly influenced by any of these levels, however, increases in volume were recorded in the afternoon collections. Motility was significantly increased in Mukota and Windsnyer and recorded to have decreased in Kolbroek, there was no significant increase in semen concentration per mL and ejaculate at these levels but semen concentration per mL was recorded to have increased in Mukota and Kolbroek and with semen concentration per ejaculate increase was recorded in Windsnyer and Kolbroek. Boar reproductive traits were influenced by varying levels of sexual stimulation, while litter size was also influenced following various levels of sexual preparations. Following 5MR, 10MR and 15MR during the morning and afternoon, both boars semen recorded to be viable and sow litter size have improved indicating the highest litter size records. This is suggesting that there were certain levels of correlation between boar fertility with sow fertility.

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