THE INCIDENCE OF ABNORMAL SPERMATOZOA IN BULL SEMEN

AND SOME CAUSES OF VARIATION

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VICTOR OLUGBADE SEKONI

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Dedicated to:

Kehinde Sekoni, my mother, Daniel Adesina Sekoni, my late father, S. A. S. Sowemimo and S. G. Sowemimo, my uncles who have always been kind and helpful to my sisters and myself.

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CHAPTER I

INTRODUCTION

A relationship between the incidence of abnormal spermatozoa and infertility is well established in the bull (among others, Williams and Savage, 1920), Lagerlof (1934, 1936), Rollinson (1951), Blom (1959, 1966), Saacke (1968), Melrose (1970), Rao (1971), Peet and Micke (1976). Evaluation of sperm morphology is, therefore, an important aspect of semen evaluation for bull selections for purposes of natural breeding or artificial insemination. The methods for semen collection and for preparing the specimens for microscopic examinations have changed considerably since the time of the initial studies by Williams et al. (1920) and Lagerlof (1934). For example new fixation solutions for wet fixations of spermatozoa immediately after ejaculation have been developed allowing evaluation with the phase contrast microscope. Furthermore, the bull material has changed due to selection and management.

Despite the availability of modern techniques and the fact that certain sperm abnormalities cannot be detected with the simple staining techniques (see for example Bane and Nicander, 1965), these are still in extensive use all over the world for the evaluation of all kinds of sperm defects. One reason might be that many countries lack specialized semen laboratories to which samples can be sent for examination. Another is that semen evaluation under field conditions require a very simple technique and equipment. Only limited information is available about the possibilities to preserve the sample at

the collection and examine it later at a clinic or semen laboratory (Dott et al., 1975).

Also, studies on the influence of smearing and staining on sperm morphology in comparison with the morphology in wet fixed specimens are very limited, Campbell et al. (1960), Bryan (1970), Harasmowycz et al. (1976).

In many countries it would be a great advantage if the semen collected in the field could be adequately prepared immediately after collection and brought to the laboratory for evaluation without losing the accuracy and reliability of result.

An evaluation of a bull's sperm morphology should be based on results obtained from normally fertile bulls which have been examined with the most accurate methods. In order to provide an adequate evaluation of a bull's spermiogram from a morphologic aspect, it is, therefore, necessary to establish values for the different sperm characteristics related to age and season in bulls.

Consequently, the objects of the present investigations were:

1. To study the possible influence on sperm morphology of different techniques in preparation and staining of the semen.
2. To establish values for different sperm morphologic characteristics and variations with age and season in bulls regularly used in artificial insemination.

Studies on the first objective are referred to as study 1 and on the second study as study 2. Specifically the first objective comprises the following studies of the same ejaculate:

I. Light microscopy of smears prepared immediately after collection from semen mixed with eosin nigrosin on a warm glass slide.

II. Light microscopy of unstained smears prepared immediately after collection and stained with modified William's stain in the laboratory within a week.

III. Semen wet fixed in buffered formal saline immediately after collection and handled and examined according to the following:

a) Phase microscopy shortly after the fixation (one to three days) and after a month storage at $+4^{o}C$ (refrigerator).

b) Light microscopy of smears from the wet fixed semen mixed with eosin nigrosin on a glass slide prepared and examined shortly after the fixation and after storage of the fixed semen for a month at $+4^{o}C$.

c) Light microscopy of Williams stained smears from the wet fixed semen prepared immediately after the collection and after one month storage of the fixed semen at $+4^{o}C$.

I. To establish values for different sperm morphologic characteristics and variations with age and season in bulls regularly used in artificial insemination.

II. To find out if there is correlation between morphological abnormalities and non-return rate.

CHAPTER II

REVIEW OF THE LITERATURE

Several studies have been done with regards to the sperm morphology of the bovine. The first one to show that pathological spermatozoa lower fertility was Williams et al. (1920). Lagerlof (1934, 1936) found the semen of fertile bulls to contain 10-11% of morphological abnormal spermatozoa while those of sterile bulls or bulls of low fertility had over 35% abnormality. Lagerlof stated that pathological sperm in bull with good fertility should not exceed 17-18%. He also showed that the occurrence of pathological spermatozoa was connected with disturbances in spermatogenesis which occur chiefly in association with testicular hypoplasia, degenerative changes in the epithelium of the seminiferous tubules, and inflammatory changes in the testicle or epididymis. According to him, increased numbers of proximal cytoplasmic droplets indicate either degeneration or regeneration processes of the spermatogenic epithelium but might in rare cases reflect an epididymal dysfunction. Lagerlof classified different types of abnormal spermatozoa e.g., abnormal shape of the head, abnormal size, double heads or tails, abnormalities of the mid-piece or tail, deficient staining capacity, loose heads, big giant head and the occurrence of proximal cytoplasmic droplets.

Blom (1950a) classified sperm abnormalities into primary and secondary and considered tissue cells other than sperm cells. The primary abnormalities were due to faulty spermatogenesis while the secondary abnormalities were acquired after the spermatozoa had left the spermatogenic epithelium. He used the semen of 100 fertile Danish

bulls for his classification. The maximum percentage of primary abnormalities was 10.4%. He observed that 15% of primary sperm abnormality lead to impairment of fertility. The cause of the abnormalities was either testicular degeneration or hypoplasia. He found testicular hypoplasia rare in Danish bulls, this is in contrast to the findings of Lagerlof 1934 in Swedish bulls. Strongly refractive acrosomal formation at the anterior margin was also classified as a primary abnormality by Blom. It is caused by the remnant of galea capitis. This defect is thought to be hereditary.

The secondary sperm abnormalities were classified by Blom (1950a) into five categories. The abnormalities are loose normal sperm heads, an increase in their number could be the first morphological manifestation of testicular degeneration. Sperms with proximal droplets are also called immature sperm. Sperm with distal droplets should not exceed 20-25% in fertile bulls. Sperm with bent tails average 4.01%. Over 30% bent tails indicate impaired fertility.

Blom (1950a) found an average of 4.6% of primary abnormal forms in 100 fertile bulls, 2.11% loose, normal sperm heads and 4.01% of bent tails.

Rao (1971) proposed that some sperm head defects e.g., narrow heads, short broad heads may be considered to be normal morphological variations since they were not connected with any pathological conditions in the testicles. Blom (1973) suggested that the division of pathological spermatozoa into primary and secondary abnormalities, which he had previously proposed (Blom, 1950a), should be changed to major and minor sperm defects. For example, the disturbances that cause the per-

sistence of proximal droplets could be localized in the spermatogenic epithelium instead of epididymal duct, furthermore the origin of certain serious tail defects is the epididymal duct, therefore the formation site for spermatozoa does not give a rationale background for classification.

Rollinson (1951) studied several groups of bulls of varying fertility. He obtained values for the abnormal spermatozoa of various categories. He obtained a percentage of 11.8 abnormal spermatozoa in fertile semen which compares well with Lagerlof (1934) who obtained a value of 10-11%. Rollinson found that fertile semen had lowest number of abnormal spermatozoa while subfertile had the greatest number. He had the view that sperm tail abnormalities (coiled, bent) result from epididymal dysfunction which was later confirmed by Gustafsson (1962, 1965, 1966, 1972), Gustafsson and Crabo (1971), Gustafsson et al. (1971, 1974).

Melrose (1970) found 4.6-10.6% of primary abnormalities in semen of normal fertile bulls, while proximal droplets averaged 2-3%. Melrose states that primary abnormalities should never exceed 15-20% in normal bulls. Zemjanis (1970) had the following values for bulls with normal fertility: abnormal forms 10-20%, proximal droplets 2-3%, detachment of acrosome 5%, bent tails less than 10% in acceptable semen.

Rao (1971) found the average proportion of abnormal heads in the ejaculate to be 6.0% in normal and 26% in abnormal bulls, while that of cytoplasmic droplets was 2% and 33%, respectively. Middle piece abnormalities in the ejaculate averaged 0.8% in normal and 2%

in subfertile bulls. Sperm tail abnormalities were 3.5% and 8.4%, respectively. The proportion of abnormal heads in the ejaculate was 4.8% in young bulls (not more than 3 years old), 6% in bulls (3-9 years old) and 11% in healthy old bulls (more than 9 years old) while that of proximal cytoplasmic droplet was 0.8%, 1.9 and 4.3% in the three groups, respectively. The finding in old bulls was attributed to an increase in testicular interstitial connective tissue and the occurrence of tubules having atrophic germinal epithelium and of spermiostatic tubules with advancing age. The age of the bull should be taken into consideration in morphological studies.

Some specific pathological forms of bull spermatozoa

Hancock (1955) working with sterile Guernsey bulls observed that the disintegration of spermatozoa into isolated heads and tails occurred in the epididymis as a result of inflammatory changes in the reproductive tract and treatments which may raise or lower testicular temperature, this agrees with Lagerlof's (1934) observations. Gustafsson (1965 , 1966) had results indicating that in testicular injury involving diminished production of sperm the epididymal plasma assumes a changed composition which might cause high incidence of sperm defects in the epididymis particularly as regards sperm tails (bent tails) and detached heads.

Blom (1959) reported a rare sperm abnormality "corkscrew sperm" associated with sterility in bulls. An earlier study by Blom in 1950 on 100 fertile bulls showed that middle piece defects accounted for only 0.25% of the primary abnormalities. Corkscrew shaped middle

pieces were found by Blom in two bulls that were 5 and 12 years old, respectively. The bulls became infertile after onset of the abnormality. Motility was nearly nil, abnormality was 6-49% and was caused by testicular degeneration. Blom (1968) noticed a major sperm defect which was defined as a well characterized primary defect occurring in 10-15% or more of the sperm population and with apparent significance for lowered fertility. The defect was called the pseudo-droplet defect found since 1962 in five young Friesian bulls but rarely in Danish bulls. It is characterized by a local thickening somewhere along the middle piece, could be smaller or similar in size as the cytoplasmic droplet, at times elongated and often localized near the center of the middle piece. The defect is found in both live and dead spermatozoa. The defect may also be hereditary as demonstrated in two brothers. Peet (1976) reported the swollen abaxial midpiece spermatozoan defects in bulls. Vale Filho et al. (1976) reported the occurrence of middle piece defects in 6 bulls. The incidence of affected spermatozoa ranged from 12-100%. Investigations revealed the transmissible nature of the defect.

Blom (1966a) reported a sterilizing and hereditary defect, the "Dag defect" located in the sperm tails of an 11 month old bull, motility was very low and 40% of spermatozoa tails were strongly coiled, folded together or split into fibers. The Dag defect is hereditary and was present in a younger brother of Dag. The incidence this time was 24%. Blom et al. (1966) studied the ultrastructure of "Dag defect" and reported that a one-sided disappearance of a group of fibers may explain the coiling. Blom et al. (1976) found

high zinc content of spermatozoa of four bulls with the "Dag defect" in Jersey bulls. Zinc may be a possible causal factor in the sterilizing sperm tail defect. Similar results have been obtained in coiled sperm tails in humans. However, the defect may arise in the epididymis and could be indicative of epididymal dysfunction (Koefoed-Johnson and Pedersen, H., 1971).

Saacke *et al.* (1968) found that some acrosomal cap abnormalities of sperm from subfertile bulls ranged from 5-20%. These abnormalities were found to be heritable.

Bane (1965) reported incidence of pouch formations of the nuclear envelope of bovine sperm. Pouch formation is due to invaginations of the nuclear envelope and is a sign of disturbed spermatogenesis. The abnormalities appeared as sparkling round or elongated white spots distinct from the other parts of the head. In most of the defective spermatozoa was also observed with phase constrast microscopy a long string of beadlike structures (impression of a necklace) at the level of the anterior border of the post nuclear cap. The feature was marked in pyriform head. Similar beads were present in the anterior part of the head particularly along the convex anterior border. Coulter (1976) also observed with phase contrast microscopy mouthed nuclear invaginations ("crater defect") of the bovine spermatozoa which increased with dexamethasone administration. The aetiology is unknown but could be viral.

Some factors which alter normal sperm morphology

Origin of sperm defects

William *et al.* (1920) from studies on sterile bulls, stated that

sterility of varying degrees resulted from faulty spermatogenesis. Lagerlof (1934, 1936) proved conclusively that many morphologically abnormal spermatozoa resulted from testicular malfunction. McEntee (1958) working on 91 sterile old bulls obtained various lesions in their testes which included focal tubular degeneration, calcified tubules and interstitial cell tumor. The bulls also had poor quality semen. Branton et al. (1947) working on six bulls concluded that the testis was the original source of morphologically abnormal spermatozoa. Swanson et al. (1962) also showed that coiled and bent tails result from epididymal malfunction. Cupps et al. (1965) gave supplementary estrogen to four bulls that subsequently produced large numbers of spermatozoa with looped or bent tails as a result of epididymal epithelium degeneration which was corrected by administration of supplementary testosterone. Gustafsson (1966) gave intramuscular injections of oestradiol benzoate. At varying intervals from the beginning of the hormone injections the semen quality deteriorated. Gustafsson et al. (1972) reported two cases of epididymal dysfunction with high incidence of sperm tail abnormalities. Thus impairment of the epididymis causes the occurrence of some sperm morphological abnormalities.

Genetic factor and disease

Bane (1954) working on identical twin bulls found genetic influence on the frequency and total number of abnormal sperm heads and cytoplasmic droplets. He also found that, disease however minor, could influence the semen picture. In two cases of lameness and anorexia, the frequency of abnormal sperm heads and proximal droplets

remained high for two years. Burges et al. (1975) found high incidence of midpiece abnormalities in bovine semen following experimental and natural cases of bovine ephemeral fever. The investigator was not sure whether the sperm defects resulted from the viral growth in the testis or the pyrexia which occurred. Many investigators (Lagerlof 1936, Gustafsson 1966) showed that scrotal insulation causes the production of abnormal sperm cells by the testicles due to elevated testicular temperature.

Osmotic pressure

Pusley et al. (1950) studied the effects of hypertonic and hypotonic solutions on the livability and morphology of bovine spermatozoa. They found that the optimum range for sperm survival was -0.44 to .061 in terms of freezing point depressions or 2.3% to 3.5% in terms of sodium dihydrate concentrations. There was little difference in the sperm head dimensions in the various hypertonic and hypotonic solutions. Coiled tails were observed in the two strongest hypotonic solutions and the strongest solution. Kollicker (1856) noted that treatment of mammallian sperm with water causes coiling and spiralization. The result was confirmed by Drevius (1963) on bull, man and rabbit. Dispiralization sets in after spiralization at a higher degree of hypotonicity. Repeated washing, cold shock, aging and storing are inhibitory to spiralization. Spiralization is a result of a flux of ions or other low molecular weight substances into the medium, causing disturbances in the contractions relaxation mechanisms. Also from in vivo results Gustafsson et al. (1974) indicated that abnormal osmotic pressure could cause sperm tail abnormali-

ties.

Frequency of ejaculation

Webster (1932) observed that after a period of sexual rest the bulls' semen is characterized by poor motility, 50% of abnormality characterized by degenerated nuclei and free heads. Subsequent samples may be of high quality.

Wells et al. (1970) observed that a period of four weeks or more of sexual rest resulted in large increases in aged acrosomes (rough or irregularly surfaced), an ejaculation frequency of four times weekly reduced aged acrosomes and maintained significantly fewer than a frequency of once weekly. The workers also stated that the acrosome is labile and susceptible to internal or external environmental circumstances or both, thus at higher frequencies of ejaculation sperms will spend less time in the epididymis for acrosomal aging to occur. Therefore, judicious use of frequent ejaculations will result in greater harvest of sperm cells. Hopwood et al. (1963) investigated the effect of exhaustive ejaculation on the composition of bovine semen, the workers found that sperm concentration is highest during earlier ejaculates and declines steadily in subsequent ejaculates with but few exceptions. It was also found that in an infertile bull abnormal sperm of the secondary type decreased as primary abnormalities increased. The percentage of live sperm also increased during exhaustive ejaculation. Other studies involving exhaustion tests have clearly shown that in cases of sperm defects of epididymal origin leading to tail changes, the semen picture improves

with increased number of ejaculates. It has been suggested (Gustafsson, 1972) that an exhaustion test involving as many ejaculates as possible within a short time (few hours) would be useful for the differential diagnosis of epididymal dysfunction. Campbell et al. (1960) found that the frequencies for all classes of morphologically abnormal spermatozoa differed significantly between ejaculates with bulls and between bulls within breeds.

The effect of season and age on sperm morphology

Many researchers have found seasonal variations in the bulls' semen pictures. Hultnas (1959) observed significant annual variations for sperm with abnormal heads and narrow heads in young bulls of Swedish red and white breed tested in September and April. Wells et al. (1972) found a significant weekly and monthly variation in the percentage of aged acrosome (rough or irregular surfaces) with late fall and winter conditions being more detrimental. Igboeli (1971) also found that in the hot season the Angoni (short horn Zebu) bulls have a higher incidence of secondary abnormalities and increased protoplasmic droplets.

Some workers have also investigated the effect of age on the bulls' semen picture. Hahn et al. (1969) found that the percentage of morphologically normal spermatozoa in semen at the time of collection and of motile sperm after freezing in pellets and ampoules were lowest in the aged holstein bulls. Bishop (1970) found that fertility declined with age after four years in bulls. Robert (1971) states that only 28% of nearly 9,000 dairy sires used artificially were

useful at 10 years of age and older. Kaderli et al. (1975) found high correlations between testicular weight and age in all the bulls. Age also had a positive influence on the number of spermatozoa. Rao (1971) also demonstrated that age has an affect on sperm morphology.

Ambient temperature

Meyerhoeffer et al. (1978) observed that after three weeks of exposure of bulls to elevated ambient temperature there was an increase in percentage of aged acrosomes, and after eight weeks of exposure there was a reduction in sperm quality although semen volume was not altered. Da Silva et al. (1976) found the direct exposure of Zebu bulls to temperature above 30°C during the first three weeks of spermatogenesis led to a decrease in semen quality and high correlations with proportions of primary and secondary abnormality.

Staining technique

There is no doubt that some stains employed for morphological studies and the methods employed produce artefacts and inaccurate results. Apart from Salisbury and N.L. VanDemark (1961) very little investigation has been done on the techniques employed for semen evaluation. Campbell et al. (1960) showed that eosin - Nigrosin gave inaccurate results as far as morphological studies are concerned. Harasmowycz et al. (1976) reported that highest repeatability in evaluation of morphological features were obtained by counting 400 spermatozoa on wet preparations of unstained, fixed semen samples using phase contrast microscopy as compared to evaluation of stained dry smears and using bright field microscopy. The stains used were

Wells - Awa, Hancocks and Bloms, unstained wet preparations were in buffered glutaraldehyde and formal saline. The most accurate results were in the wet preparations, formal saline was the most reliable. It was also observed that the procedures for preparing smears seem detrimental to the acrosome. Dott et al. (1975) using the semen of different species with bovine inclusive found that formal saline or formal citrate were very reliable for the preservation of differential staining of spermatozoa kept at $4^{o}C$ - $40^{o}C$ for periods of three weeks. Bryan (1970) found using eosin - fast green napthol yellow mixture stain to be reliable and accurate for the differential staining of cytologic components in many mammalian species with the bovine inclusive.

CHAPTER III

SURVEY OF MATERIAL AND METHODS

Study 1

The effects of preparation, fixation in buffered formal saline, storage at +4°C, and staining techniques on sperm morphology and on the percentage of live and dead spermatozoa.

Animals

A total of 27 beef bulls were used in this study, 21 of the bulls were of the Angus breed and 6 of the Hereford breed. Semen collection was by the electro-ejaculation technique for a regular breeding soundness examination in the months of March and April of 1977. All precautions were taken to prevent cold shock. Semen collections were done with prewarmed clean tubes which were also immersed in a jacket containing warm water (37°C). Immediately after the measurement of scrotal circumference, semen collection and examination of the sperm motility semen was prepared as follows:

I. Direct smear with eosin-nigrosin from fresh semen were done for each ejaculate by touching a spreader slide to a drop of the mixture of stain and raw semen (5:1) and then drawing the mixture across the surface of a prewarmed clean slide at 45° angle.

II. Direct smears were made on prewarmed clean slide and stained later (within 3 days) in the laboratory with modified Williams stain.

III. 0.5 ml of the fresh semen was transferred to a test tube

containing 5 mls of buffered formal saline at 37°C. The formal saline fixed semen was used for phase contrast microscopy and for preparation of stained smears after 1 month storage at +4°C (See Introduction: Objectives).

The preparation of stained smears with carbol-fuchsin eosin according to the method described by Williams, 1920 and modified by Lagerlof, 1934.

Williams staining:

1. Preparation of semen smears
2. Drying in air and fixation over heat
3. Three to four minutes in absolute alcohol
4. One to two minutes treatment with ¼% chloramine solution until the mucus disappears and smears become fairly clear
5. Rinsing in distilled water followed by 96% alcohol. A little alcohol left floating on the slides
6. Staining with carbol-fuchsin eosin for six to ten minutes
7. Rinsing in tap water
8. Drying in air

Laboratory examinations

Semen wet fixed in buffered formal saline immediately after collection was handled and examined according to the following:

a) examined in phase contrast microscope shortly after the fixation (1-3 days) and after a month's storage at +4°C.

Wet preparations under small coverslip were made by placing a drop of the fixed semen on the center of a clean slide and a coverslip was put on the drop. Care was taken to ensure that no air bubbles and immersion oil got under the coverslip. The wet preparation under small coverslips was then examined and counted in a regular sequence with phase contrast microscopy at a magnification of X1000 for the following abnormalities: abnormal acrosomes, detached normal heads, detached abnormal heads, proximal cytoplasmic droplets, distal *cytoplasmic droplets, abnormal mid-piece and sperm tail abnormalities.* A total of 400 well spaced spermatozoa were carefully examined in each preparation by scanning.

The morphologic characteristics studied were the following:

Cytoplasmic Droplets

I. Proximal

II. Distal

Sperm Tail Abnormalities

I. Simple Bent

II. Coiled

III. Coiled Around the Head

IV. Others

Tail Less Heads

I. Normal Head Morphology

II. Abnormal Head Morphology

Middle Piece Abnormalities

I. Swollen

II. Double

III. Rough

IV. Abaxial Attachment

V. Coiled

VI. Others

Acrosome (Apical Cap)

I. Detached Acrosome

II. Rough

III. Irregularly Surfaced

The Study of Head Morphological Abnormalities

The stained smears (eosin-nigrosin and Williams' stain) were used for the study of head abnormalities. Five hundred spermatozoa were counted systematically in each smear at a magnification of X1000 under oil immersion.

Head abnormalities studied were:

1. Narrow
2. Narrow at the base
3. Pear shaped
4. Abnormal contour
5. Small normal
6. Small abnormal
7. Short broad
8. Undeveloped

9. Micro
10. Giant
11. Double
12. Tail less pathological

In addition to the study of head shape abnormalities, the stained smears were also used to study all the abnormalities studied under wet preparation. These include cytoplasmic droplets, sperm tail abnormalities, tail less heads, middle piece abnormalities and acrosome abnormalities.

Estimation of the percentage live and dead sperm cells

Semen smears stained with eosin Nigrosin were, besides for the sperm morphology evaluation, used for the evaluation of the dead and live sperm cells. Four hundred sperm cells were counted per stained smears. The dead sperm cells absorb the stain while the live ones do not.

Study 2

The incidence of sperm abnormalities in bulls regulary used in artificial insemination with aspects on the effects of age and season and correlation of some sperm morphological abnormalities to nonreturn rate.

Animals

A total of 44 dairy bulls were used in this study. All the bulls were of the Holstein breed regularly collected at A.I. center.

Fertility records and health records of the bulls were secured where available. The housing units and the temperature within were

checked for certain periods.

Methods

The bulls used were collected once a week by the artificial vagina method. Semen samples were taken from pooled ejaculates for each bull. One semen sample a month per bull was examined. The investigations continued over a period of one year. The number of dairy bulls sampled varied from 26 in May to 41 in August and September of 1977. Only nineteen of the dairy bulls were sampled all 12 months of the year. The bulls were used to study the influence of age and season on sperm morphology and the correlation of non-return rate to morphological abnormalities.

Immediately after semen collection 0.05 ml was transferred to a glass vial containing 0.8 ml of buffered formal saline solution. The semen samples were studied with phase and light microscopy within two weeks after collection, fixation and storage at $+4^{\circ}C$.

Examination of semen with the phase contrast microscope

Semen wet fixed in buffered formal saline immediately after collection were examined exactly as described for study 1.

The preparation of stained smears with modified Williams' stain

Decantation of buffered formal saline was done and smears were made from the fixed semen.

Smears were stained and head morphological abnormalities studied exactly as done in study 1.

Methods of statistical analysis

Each variable was analyzed by a randomized block two way analysis

of variance. Data were blocked by bulls. Differences between the three methods of observing sperm morphology and between no storage (one day) and one month storage were examined by individual orthogonal contrasts. Means that had a probability of 0.05 or less of being from the same population were reported as significantly different. The same analysis was used to examine the effects of season and age on sperm morphology.

Means with different superscripts in the tables are significantly different.

CHAPTER IV

THE EFFECTS OF PREPARATION, FIXATION IN BUFFERED FORMAL SALINE, AND STAINING TECHNIQUES ON SPERM MORPHOLOGY AND ON THE PERCENTAGE OF LIVE AND DEAD SPERMATOZOA

Results

Pathologic sperm head

The results for abnormal sperm heads studied with stained smear preparations of eosin nigrosin and Williams stain and studied with only the light microscope are presented in table 1. Fresh semen smears stained with eosin nigrosin on day zero and studied with the light microscope had a mean of 3.24% head abnormalities. Semen fixed in buffered formal saline and stored for a month at +4°C and stained with eosin nigrosin had a mean of 3.79% head morphological abnormalities. A month later, after fixation in buffered formal saline and storage at +4°C staining with Williams stain and studying with the light microscope, a mean of 3.16% head abnormalities was obtained which is not significantly different from the mean of 2.86% obtained on day zero. The results obtained on day zero for fresh semen smears stained with eosin nigrosin and Williams stain did not differ significantly from those obtained a month later after the semen had been fixed in buffered formal saline and stored at +4°C.

Acrosome abnormalities (rough, irregularly contoured, detached)

See table 1 and the appendix for the results obtained. The mean obtained for acrosomal abnormalities for semen fixed in buffered formal saline and studied on day zero with the phase contrast micro-

Table 1
Percentage of Sperm Abnormalities in 27 Beef Bulls Using Three Different Methods of Preparation and Staining on Day Zero and at a Month After Fixation and Storage at 4°C

COMPARISONS	1		2		3	
	FSo	FS_1	ENo	EN_1	WSo	WS_1
Number of Bulls	27	27	27	27	27	27
ABNORMALITIES[a]						
Head Abnormalities			3.24 (3.00)	3.79 (3.27)	2.86 (2.05)	3.16 (2.81)
Acrosome Abnormalities	1.35 (3.53)	1.37 (3.83)	0.62 (2.00)	0.78 (1.69)	0.45 (1.19)	0.94 (3.16)
Proximal Droplets	6.98 (17.26)	6.23 (17.13)	5.00 (13.33)	3.93 (12.86)	2.30 (9.26)	3.52 (14.03)
Distal Droplets	4.34 (5.70)	4.27 (4.76)	2.91 (2.79)	1.48 (1.40	1.04 (1.19)	1.41 (1.99)
Mid Piece Abnormalities	1.04 (0.94)	1.05 (0.87)	0.48 (0.48)	0.85 (1.11)	0.94 (1.01)	1.23 (1.36)
Abaxial Attachment	0.50 (0.14)	0.04 (0.09)	0.04 (0.13)	0.01 (0.05)	0.05 (0.16)	0.10 (0.20)
Sperm Tails	7.26 (8.20)	6.53 (8.04)	6.42 (7.94)	7.73 (9.99)	4.49 (5.57)	6.23 (7.75)
Detached Normal Sperm Heads	2.93 (5.94)	3.06 (5.59)	3.46* (6.79)	9.69* (10.79)	1.75 (1.75)	3.73 (3.76)

For proximal droplets, distal droplets acrosome abnormalities, FSo significantly different from ENo, WSo ($P<0.05$)

For detached normal sperm head, distal droplets, acrosome abnormalities FS_1 significantly different from EN_1, WS_1 ($P<0.05$)

FSo = Semen fixed in buffered formal saline on day zero and studied with phase microscope
FS_1 = Semen fixed in buffered formal saline after a month storage at +4°C and studied with phase microscope
ENo = Fresh semen smears stained with eosin nigrosin on day zero and studied with the light microscope
EN_1 = Smears made from semen fixed in buffered formal saline and stained with eosin nigrosin after a month storage at +4°C and studied with the light microscope
WSo = Fresh semen smears stained with Williams stain on day zero and studied with the light microscope
WS_1 = Smears made from semen fixed in buffered formal saline and stained with Williams' stain after a month storage at +4°C and studied with the light microscope

[a]The table shows the mean percentage of abnormalities for 27 bulls and standard deviation parenthetically
*Means were significantly different ($P<0.05$) for day zero and at a month. Test of significance were made by orthogonal contrasts in a randomized block analysis of variance using an error term with 161° freedom

scope was 1.35% while a month later after fixation and storage at +4°C the mean was 1.37°C. The results for day zero and a month were not significantly different. Fresh unfixed semen smears stained on day zero with eosin nigrosin and studied with the light microscope had a mean of 0.62%, a month later after fixation in buffered formal saline and storage at +4°C the mean was 0.78% which is not significantly different from that on day zero. Fresh semen smears stained with Williams stain on day zero had a mean of 0.45% while after fixation in buffered formal saline and storage at +4°C the mean was 0.94% when studied with the light microscope. The two results are not significantly different. However, the mean of 1.35% of acrosomal abnormalities obtained on day zero in semen fixed in buffered formal saline and studied with the phase contrast microscope was significantly different from the mean of fresh semen smears stained with eosin nigrosin ($P<0.01$) and Williams' stain ($P<0.001$) on day zero. The mean of 1.37% obtained with the phase microscope for acrosomal abnormalities in semen fixed in buffered formal saline and stored at +4°C for a month did not differ significantly from the mean of smears of semen fixed in buffered formal saline and stained with eosin nigrosin after a month's storage at +4°C and studied with the light microscope. The mean (1.37%) differed ($P<0.001$) from the mean of semen fixed in buffered formal saline and stored at +4°C for a month before being stained and studied with the light microscope. There was no significant difference between day zero and a month for all methods.

Proximal cytoplasmic droplets

As can be seen from table 1 the highest percentage of proximal cytoplasmic droplets was recorded under the phase contrast microscope in semen fixed in buffered formal saline immediately after semen collection. The result obtained with the phase microscope was 6.98% and this was significantly different ($P<0.01$) from 5% obtained with fresh semen stained with eosin nigrosin and from 2.30% ($P<0.001$) from fresh semen smears stained with Williams' stain and studied with the light microscope immediately after semen collection. After a month's fixation in buffered formal saline at a temperature of $+4^{o}C$, the evaluation of the proximal droplets was again done with the phase microscope and the light microscope. The wet fixed semen studied with the phase microscope had a mean of 6.23% which differed ($P<0.001$) from 3.93% for semen smears stained with eosin nigrosin after a month's fixation in buffered formal saline and storage at $+4^{o}C$, but the value did not differ significantly from 3.52% for semen smears stained with Williams' stain after a month's fixation in buffered formal saline and storage at $+4^{o}C$. The results obtained with wet fixed semen on day zero did not differ significantly from that obtained at a month after storage at $+4^{o}C$ and evaluation with the phase microscope. Similarly the results obtained for fresh semen smears stained with eosin nigrosin and studied with the light microscope on day zero did not differ significantly from that obtained with semen fixed in buffered formal saline, stored at $+4^{o}C$ and studied with the light microscope.

Distal cytoplasmic droplets

See table 1 and the appendix for detailed results.

The highest percentage of distal cytoplasmic droplets was recorded with the phase contrast microscope in semen fixed in buffered formal saline and studied immediately after semen collection. A mean of 4.34% of distal cytoplasmic droplets was obtained which was not significantly different from 2.91% obtained with fresh semen stained with eosin nigrosin but different ($P<0.001$) from 1.04% obtained with fresh semen stained with Williams' stain. A month later after fixation in buffered formal saline and storage at $+4^{o}C$ a count of the distal cytoplasmic droplets was repeated using wet fixation and phase microscope and the light microscope. The wet fixed semen in buffered formal saline studied with the phase microscope had a mean of 4.27% which differs significantly ($P<0.001$) from 1.48% for semen smears stained with eosin nigrosin after a month's fixation in buffered formal saline and storage at $+4^{o}C$. The value (4.2%) also differs significantly ($P<0.001$) from 1.41% for semen smears stained with Williams' stain after a month's fixation in buffered formal saline and storage at $+4^{o}C$. The results obtained with wet fixed semen on day zero did not differ significantly from that obtained at a month after storage at $+4^{o}C$ and evaluation with the phase microscope. Similarly the results obtained for fresh semen smears stained with eosin nigrosin and studied with the light microscope on day zero did not differ significantly from that obtained with semen fixed in buffered formal saline, stored at $+4^{o}C$ and studied with the light microscope.

Middle-piece abnormalities (double, coiled, rough, swollen)

See table 1 and the appendix for the results.

The results obtained on day zero were not significantly different from those obtained a month later after fixation and storage at +4°C. The mean for the fixed semen in buffered formal saline on day zero studied with the phase microscope was 1.04% midpiece abnormalities while a month later following storage at +4°C and fixation in buffered formal saline a mean of 1.05% was obtained. Fresh semen smears stained with eosin nigrosin on day zero and studied with the light microscope had a mean of 0.48% midpiece abnormalities, fixed semen smears stained with eosin nigrosin after a month's storage at +4°C in the cold room had a mean of 0.85%. Fresh semen smears stained with Williams stain and studied with the light microscope on day zero had a mean of 0.94% midpiece abnormalities while following fixation in buffered formal saline and a month's storage at +4°C the mean was 1.23% for smears stained with Williams stain and studied with the light microscope.

Abaxial attachment of the middle-piece

The results are shown in table 1. The percentages of abaxial attachment of the middle piece was low with all methods of evaluation. No statistical test for significant differences were done. Fresh semen fixed in buffered formal saline and studied with the phase microscope had a mean of 0.05% of abaxial attachment of the midpiece while a month later after fixation and storage at +4°C the mean was 0.04%. In fresh semen smears stained with eosin nigrosin on day zero and studied with the light microscope the mean for abaxial attachment

of the midpiece was 0.04% while a month later after fixation in buffered formal saline and storage at +4°C the mean for smears stained with Williams stain and studied with the light microscope on day zero the mean was 0.05% and a month later, after fixation in buffered formal saline and storage at +4°C the mean with the same stain and same method of observation was 0.10%.

Sperm-tail Abnormalities

The results are presented in table 1. The results obtained on day zero were not significantly different from those obtained a month later after fixation in buffered formal saline and storage at +4°C. The mean for semen fixed in buffered formal saline shortly after collection on day zero with the phase microscope was 7.26% tail abnormalities while a month later following fixation and storage at +4°C the mean was 6.35% tail abnormalities. Fresh semen smears stained with eosin nigrosin on day zero and studied with the light microscope had a mean of 6.42% for tail abnormalities. Buffered formal saline fixed semen smears stained with eosin nigrosin after a month's storage at +4°C had a mean of 7.73% tail abnormalities when studied with the light microscope. Fresh semen smears stained with Williams and studied with the light microscope on day zero had a mean of 4.49% tail abnormalities while following fixation and a month's storage at +4°C the mean was 6.23% tail abnormalities for smears stained and studied with the light microscope.

Detached normal sperm head

The result for detached normal sperm heads are also presented in

table 1. On day zero, detached normal sperm heads in semen fixed in buffered formal saline and studied with the phase contrast microscope was 2.93% while a month later after fixation and storage at +4°C it was 3.06%. These results are not significantly different. The mean for the same abnormality in fresh semen stained with eosin nigrosin on day zero was 3.46% while a month later following fixation and storage the mean increased to 9.69% for semen smears stained with eosin nigrosin. The results (i.e., for day zero and a month later) were different ($P<0.001$). For fresh semen smears stained with Williams stain and studied with the light microscope on day zero the mean was 1.75% while a month later after fixation in buffered formal saline and storage at +4°C semen smears stained with the same stain had a mean of 3.73%. The result for day zero and a month later were not significantly different. The results obtained on day zero with phase and light microscopy were not signifiantly different. The mean of 3.06% for semen studied with the phase microscope after a month's fixation in buffered formal saline and storage at +4°C was different ($P<0.001$) from 9.69% for fixed smears stained with eosin nigrosin after a month's fixation and storage at +4°C. The mean of 9.69% is also different ($P<0.001$) from 3.73%, the mean for buffered formal saline fixed semen smears stained with Williams stain after a month's storage at +4°C. From this study, as can be seen from table 1, there was a trend in all methods of evaluation toward an increase in detached normal sperm heads which is only significant in fixed semen smears stained with eosin nigrosin after a month's storage at +4°C.

The affinity for supravital stain (eosin-nigrosin) of fresh semen compared to that of semen fixed in buffered formal saline and stored at +4°C for a month

The result obtained is presented in table 2. The mean percentage live spermatozoa for fresh semen stained with eosin nigrosin on day zero was 88.17%. A month after fixation in buffered formal saline and storage at +4°C the mean for live sperm cells was 88.92%. In nearly all of the semen samples studied the result obtained with fresh semen samples studied on day zero were about the same for semen samples fixed in buffered formal saline and stored at +4°C for a month. Good examples are bulls no. 1, 2, 4, 6, 13, 16, 20 21 and 24.

Discussion

The results obtained in the methodological study showed that wet fixed semen samples examined with the phase constrast microscope gave significantly higher percentage of proximal and distal cytoplasmic droplets than did the stained preparations studied with the light microscope. Detailed results in the appendix reveals that bull no. 2 had 90.5% of proximal cytoplasmic droplets in wet fixed preparation with the phase contrast microscope on the day of semen collection; a month later after fixation in buffered formal saline and storage at +4°C the mean with wet fixation was 90.0%. On day zero fresh semen smears of the same bull had a mean of 70% proximal cytoplasmic droplets when studied with the light microscope. After fixation in buffered formal saline and storage at +4°C for a month, semen smears stained with eosin nigrosin had a mean of 67.2%. Fresh semen smears of the same bull stained with Williams stain on day zero had a mean of 48.6%

Table 2
% Mean Values for Sperm Cells that Stained with Eosin Nigrosin in Fresh Semen and Semen Fixed with Buffered Formal Saline for a Month

	Immediate %	At a Month %
1	95.25	95.0
2	90.5	90.0
3	90.75	92.0
4	94.0	93.75
5	91.0	93.25
6	90.25	90
7	93.5	94.75
8	91.0	92.5
9	92.5	94.0
10	91.0	90.0
11	94.75	95.0
12	77.5	79.5
13	75.25	75.5
14	87.75	92.25
15	40.75	42.0
16	94.5	94.0
17	86.0	85.75
18	94.0	94.5
19	93.5	93.25
20	89.25	89.5
21	93.5	93.25
22	87.5	88.25
23	94.75	95.0
24	95.0	95.0
25	70.0	74.5
26	93.5	93.75
27	93.25	94.5
Mean:	88.17	88.92
SD:	11.36	10.96

of proximal cytoplasmic droplets. A month later, following storage and fixation, the mean was 14.2% which indicated that during the staining procedures most of the droplets were lost. Another bull of interest is no. 27. On day zero wet fixed semen of the bull had 17.25% of proximal cytoplasmic droplets. On the same day fresh semen stained with Williams had 0.5% of proximal cytoplasmic droplets. The same trend of having fewer droplets in the stained preparation was marked in bulls no. 10, 19, and 21. The result obtained clearly demonstrated that some droplets were lost during the staining procedures. In some cases nearly all the droplets were lost during the staining procedures. The inaccuracy produced by this trend could be critical during breeding soundness examinations if stained preparations were used only.

From the results obtained, staining semen smears with eosin nigrosin seemed detrimental to proximal and distal cytoplasmic droplets just as with staining semen smears with Williams stain. Bull no. 19 had 14.75% of proximal cytoplasmic droplets in wet fixed semen studied with the phase contrast microscopy on the day of semen collection while with fresh semen smears stained with eosin nigrosin and studied with the light microscope the bull had 8%. The same trend was true for bulls no. 20 and 21. Many bulls had about or less than 50% fewer proximal cytoplasmic droplets in fresh semen smears stained with eosin nigrosin and studied with the light microscope than in semen wet fixed in buffered formal saline and studied with phase microscopy.

The trend observed for proximal cytoplasmic droplets was also true for distal droplets. Bull no. 3 had 10.25% of distal cytoplasmic

droplets on day of semen collection in wet fixed semen studied with the phase contrast microscope, while with fresh semen smears stained with eosin nigrosin and studied with the light microscope the bull had 2%. Bull no. 4 had 11.5% of distal cytoplasmic droplets on day of semen collection in wet fixed semen studied with phase microscopy while with fresh semen smears stained eosin nigrosin and studied with the light microscope the bull had 6%. The same trend was true for bulls no. 8, 11, 13 and 19.

Detailed results for distal droplets are presented in the appendix. The result indicated that artefacts in the stained preparations may be counted as droplets. For example, bull no. 2 had no distal droplets in fixed wet preparations with phase microscopy shortly after collection and a month after storage at $+4^{o}C$. Fresh semen smears of the same bull on the day of collection had 7.25% of distal droplets with eosin nigrosin and 5.4% with Williams stain. Some artifacts in the stained preparations resemble droplets. The percentage of distal droplets with phase microscopy was different ($P<0.001$) from the results obtained from stained semen smears studied with light microscopy. The results obtained in the investigation agree with the findings of Harasmowycz et al. (1976) who reported that fixation with buffered glutaraldehyde resulted in higher counts ($P<0.01$) of proximal cytoplasmic droplets (2.41, 1.03, 0.67 and 1.43), respectively for glutaraldehyde, Hancock's, Bloms and formal saline procedures. Although not significant, the same trend was observed for distal protoplasmic droplets by the same investigators.

From this investigation the result for acrosomal abnormalities obtained with phase microscopy was significantly different from the results obtained with stained semen smears studied with light microscopy. Phase microscopy seemed better than light microscopy for the evaluation of acrosomal abnormalities.

There were more detached normal sperm heads in the stained preparations. After a month's fixation in buffered formal saline and storage at $+4^{o}C$ detached normal sperm heads counted in semen smears stained with eosin nigrosin and studied with the light microscope was significantly different ($P<0.001$) than wet fixation method with phase microscopy and buffered formal saline fixed smears stained with Williams stain and studied with light microscopy.

Also in this investigation the live and dead differential staining of spermatozoa by oesin nigrosin was preserved when semen was fixed in buffered formal saline and stored at $+4^{o}C$ for a month. The proportion of eosinophilic spermatozoa did not differ from that in fresh semen after storage. The result agrees with Dott et al. (1975).

Conclusion

From the results obtained in this study a combination of phase contrast microscopy and light microscopy seem ideal for obtaining the most reliable results in sperm morphologic evaluations. Head abnormalities could be studied with stained preparations of eosin nigrosin or Williams stain while other morphological abnormalities could be evaluated in wet fixed semen with the phase microscope.

The investigation demonstrated that buffered formal saline is a good fixative for the bulls sperm which if kept at the cold room temperature of +4^{o}C, could still give accurate results for morphological studies and the live dead differential staining with eosin nigrosin at a month. Bull semen if fixed in buffered formal saline and stored at +4^{o}C for several days could still be transported to localities where there are ideal semen laboratories for accurate evaluation.

CHAPTER V

THE INCIDENCE OF SPERM ABNORMALITIES IN BULLS REGULARLY USED IN ARTIFICIAL INSEMINATION WITH ASPECTS ON THE EFFECTS OF AGE AND SEASON AND CORRELATION OF SOME SPERM MORPHOLOGICAL ABNORMALITIES TO NONRETURN RATE.

Result

The Influence of Age on Sperm Morphology

Nineteen dairy bulls were sampled for the twelve months of 1977. They ranged in age from 1½ years to 9 years. They were divided into 3 age groups. The young bulls were aged between 1½ to 2 years, the medium aged 2½ to 4 years and the old between 5 to 8½ years. The youngest bulls in the study were aged between 6 to 12 months and they were separately considered as prepubertal bulls in this investigation.

Pathologic sperm head

Table 3 summarizes the mean annual occurrence of head abnormalities in different age groups. The percentage for head abnormalities ranged between 1.79% in the young bulls to 2.59% in the medium aged bulls. The result in the different age groups was not significantly different.

Acrosome abnormalities

Detailed results for acrosomal abnormalities are presented in the appendix. The incidence was very low in all age groups.

Table 3
1977 Percentage of Head Abnormalities in Different Age Groups of Dairy Bulls

	Young	Medium	Old
Age	1½ Yr - 2 Yr	2½ Yr - 4 Yr	5 Yr - 8½ Yr
N	7	5	7
Std. Error	0.50	0.59	0.50
Mean	1.79[a]	2.59[a]	2.41[a]

The means are not significantly different (P>0.05)

Table 4
1977 Percentage of Proximal Cytoplasmic Droplets in Different Age Groups of Dairy Bulls

	Young	Medium	Old
Age	1½ Yr - 2 Yr	2½ Yr - 4 Yr	5 Yr - 8½ Yr
N	7	5	7
Std. Error	0.84	0.99	0.84
Mean	1.97[a]	3.42[a]	2.50[a]

The means are not significantly different (P>0.05)

Proximal cytoplasmic droplets

A summary of the influence of age and occurrence of proximal cytoplasmic droplets are presented in table 4. The percentage of occurrence ranged between 1.97% in the young bulls to 3.42% in the medium aged bulls. The results in the different age groups were not significantly different.

Distal cytoplasmic droplets

A summary of the result is presented in table 5. The young bulls had 1.16% which differed ($P<0.03$) from the old bulls which had a mean of 2.65%.

Middle piece abnormalities

Detailed results for middle piece abnormalities are presented in the appendix. The incidence was low in all age groups.

Abaxial attachment of the middle piece

Detailed results for the abaxial attachment of the middle piece are presented in the appendix. The incidence was low in all age groups.

Tail abnormalities

The results for tail abnormalities are presented in table 6. The young bulls had 2.14% which differed ($P<0.03$) from the medium aged bulls and from the old bulls ($P<0.05$).

Tail less heads

The results are summarized in table 8. The results were not significantly different in the age groups.

Table 5
1977 Percentage of Distal Cytoplasmic Droplets in
Different Age Groups of Dairy Bulls

	Young	Medium	Old
Age	1½ Yr - 2 Yr	2½ Yr - 4 Yr	5 Yr - 8½ Yr
N	7	5	7
Std. Error	0.53	0.63	0.53
Mean	1.16[a]	2.17[ab]	2.65[b]

Means with different superscripts are significantly different
($P < 0.03$)

Table 6
1977 Percentage of Tail Abnormalities in
Different Age Groups of Dairy Bulls

	Young	Medium	Old
Age	1½ Yr - 2 Yr	2½ Yr - 4 Yr	5 Yr - 8½ Yr
N	7	5	7
Std. Error	1.78	2.10	1.78
Mean	2.14[a]	7.38[b]	2.81[a]

Means with different superscript are significantly different
($P < 0.05$)

Total morphological abnormalities

Table 7 summarizes the results for total morphological abnormalities. The young bulls had 9.08% which differed ($P<0.02$) from the medium aged bulls that had 18.83% and from the old bulls ($P<0.03$) that had a mean of 12.22%.

Variations in Sperm Morphology in Prepubertal Bulls Within the First Seven Months of Sampling (See Fig. 1)

There were 6 bulls in this group which were sampled from June to December 1977.

Head morphological abnormalities

Detailed results are presented in the appendix. (See figure 1) The bulls had a mean of 3.08% of head abnormalities for June, July and August which differed ($P<0.001$) from the mean for September, October, November and December which was 1.23%. The mean for June and July was 3.60% and this differed from the mean for November and December which was 1.42% ($P<0.001$).

Proximal cytoplasmic droplets

Detailed results are shown in the appendix. (See figure 1) For the months of June, July and August the bulls had a mean of 2.86% of proximal cytoplasmic droplets which differs ($P<0.001$) from the mean of 1.68% for the months of September, October, November and December. For June and July the bulls had a mean of 3.17% which differs ($P<0.001$) from the mean of 1.81% for the months of November and December.

Table 7
1977 Percentage of Tail-Less Heads in Different
Age Groups of Dairy Bulls

	Young	Medium	Old
Age	1½ Yr - 2 Yr	2½ Yr - 4 Yr	5 Yr - 8½ Yr
N	7	5	7
Std. Error	0.38	0.45	0.38
Mean	1.12[a]	1.95[a]	1.13[a]

The means are not significantly different

Table 8
1977 Total Morphological Abnormalities in Different
Age Groups of Dairy Bulls

	Young	Medium	Old
Age	1½ Yr - 2 Yr	2½ Yr - 4 Yr	5 Yr - 8½ Yr
N	7	5	7
Std. Error	2.86	3.39	2.86
Mean	9.08[a]	18.83[b]	12.22[b]

Means with different superscript are significantly different
($P < 0.02$)

Distal cytoplasmic droplets

The results are shown in the appendix.

The bulls had a mean of 1.14% of distal cytoplasmic droplets for the months of June, July, August and 1.34% for September, October, November and December. For the months of June and July the mean was 1.40% while for November and December the mean was 1.49%. There was a little increase in the mean percentage of distal cytoplasmic droplets but no significant difference for the months compared.

Tail abnormalities

The bulls had a mean of 1.54% tail abnormalities for June, July and August. For September, October, November and December the mean dropped to a value of 1.22%. For June and July the mean was 1.32% while for November and December the mean was 1.27%. The means did not differ significantly at any period of the seven months of sampling.

Discussion

From the investigation the results showed that there was a definite influence of age on sperm morphology.

The prepubertal-bulls sampled for the last seven months of the investigation had more proximal cytoplasmic droplets and head morphological abnormalities during the first few months of sampling than during the last two months. The results obtained in the prepubertal bulls of high percentage of proximal droplets and head abnormalities during the first three months of sampling is in agreement with the findings of Lagerlof (1934).

There were no significant changes noticed in the distal cytoplasmic droplets and tail abnormalities. The occurrence of high percentage

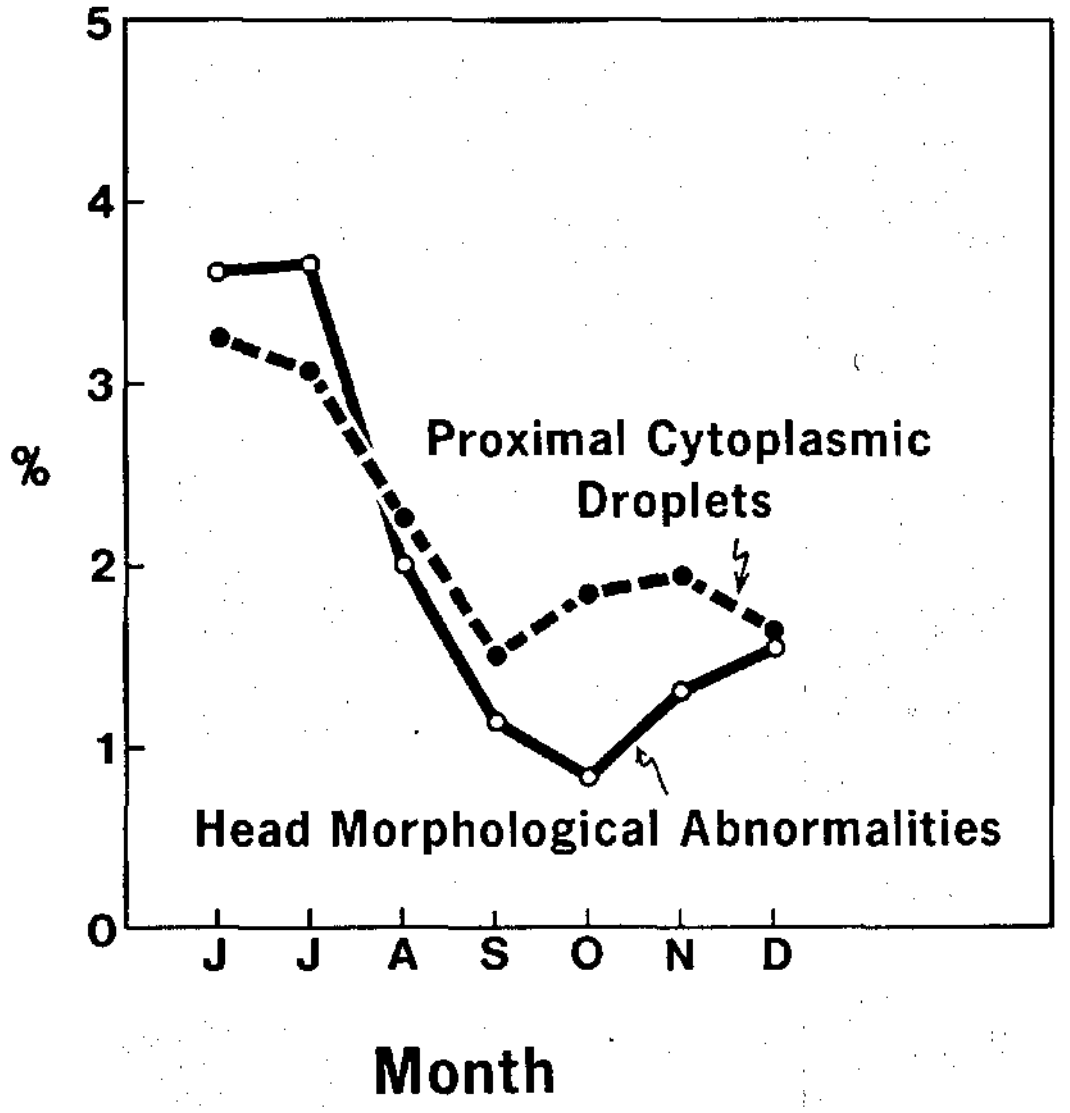


FIGURE 1. Variations in the Percentage of Proximal Cytoplasmic Droplets and Head Abnormalities in Prepubertal Bulls Within the First Seven Months of Sampling

of proximal cytoplasmic droplets and head abnormalities during the initial months of sampling were normal stages before testicular and epididymal functions got fully established.

The bulls compared to see the effect of age on sperm morphology were aged between 1½ years to 8½ years. The old bulls aged between 5 years and 8½ years had higher values for distal cytoplasmic droplets and total morphological abnormalities which differed ($P<0.02$ and $P<0.03$, respectively) from the values the young bulls had. Even though not significantly different the old bulls had more tail-less heads, tail abnormalities, and proximal droplets than the young bulls. The higher percentage of morphological abnormal spermatozoa in older bulls might occur as a part of the normal physiological process of aging which was reflected in the semen by a higher incidence of abnormal sperm heads, detached sperm heads, proximal cytoplasmic droplets and abnormal sperm tails. The mechanism involved might be an increased production of abnormal sperm heads in the testes or decreased resorption of these cells in the genital tract. Rao (1971) had results that indicate that relatively more pathological sperm heads leave the testes and enter the ductuli efferentes in old bulls than in young. Bane (1954) reported higher incidence of abnormal sperm heads and proximal cytoplasmic droplets with increased age in twin bulls. Hahn et al. (1969) found higher percentage of abnormal sperm in old bulls than in young ones. Rao (1971) found no correlation between testicular changes and the incidence of abnormal sperm tails. Gustafsson (1965, 1966) reported that in testicular injury involving diminished production of sperm the epididymal plasma assumes a changed composition which seems

to cause high incidence of sperm defects particularly bent tails and detached heads. Rao (1971) found that tail abnormalities arose mainly in the epididymis, probably under the influence of epididymal environment, i.e., under the influence of epididymal plasma. The same worker also showed that certain histological changes begin as early as the second or third year of the bull's life and increase with advancing age in a normal bull's life. Among the alterations are the increase in testicular interstitial connective tissue, increase in tubules with atrophied germinal epithelium and increase in tubules with spermiostasis. It was also shown that the appearance of any one of the alterations tends to be related to semen quality. The combined effect on spermatogenesis of the changes in medium aged and old bulls was apparently marked and explained the total number of sperm abnormalities.

"It may be pertinent to say that the normal spermiogram of bulls differs between different age groups" (Rao, 1971). The present investigation supports that view.

The Influence of Season on Sperm Morphology (See Figs. 1, 2 and 3)

Head morphological abnormalities

The result for head abnormalities during the four seasons are summarized in table 9. Summer had the highest mean of 3.72% which differed ($P<0.001$) from the winter mean of 1.72%. Spring had a mean of 1.34% which differed ($P<0.04$) from the fall mean of 2.04%. Summer differed from fall ($P<0.01$) and from spring ($P<0.001$).

Table 9
1977 Percentage Seasonal Values for Head Abnormalities in 19 Dairy Bulls

	Winter	Summer	Spring	Fall
N	3	3	3	3
Std. Error	0.42	0.42	0.42	0.42
Mean	1.72^{b}	3.72^{a}	1.34^{b}	2.04^{c}

N = number of months
Means with different superscripts are significantly different ($P<0.04$)

Table 10
1977 Percentage Seasonal Values for Proximal Cytoplasmic Droplets in 19 Dairy Bulls

	Winter	Summer	Spring	Fall
N	3	3	3	3
Std. Error	0.21	0.21	0.21	0.21
Mean	1.96^{b}	3.08^{a}	2.79^{c}	2.36^{c}

N = number of months
Means with different superscripts are significantly different ($P<0.02$)

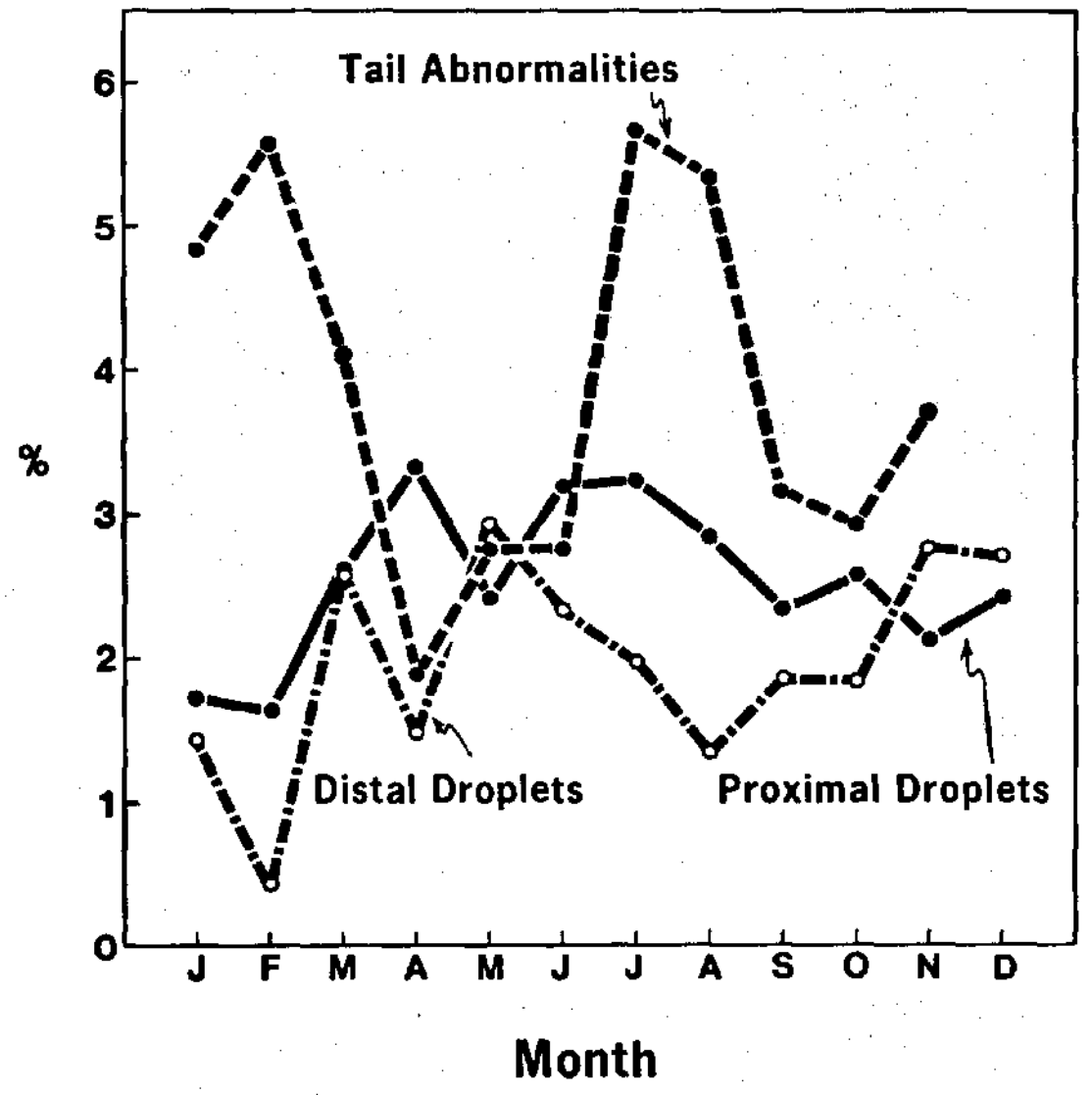


FIGURE 2. Seasonal Variations of Droplets and Tail Abnormalities of the Bovine Semen

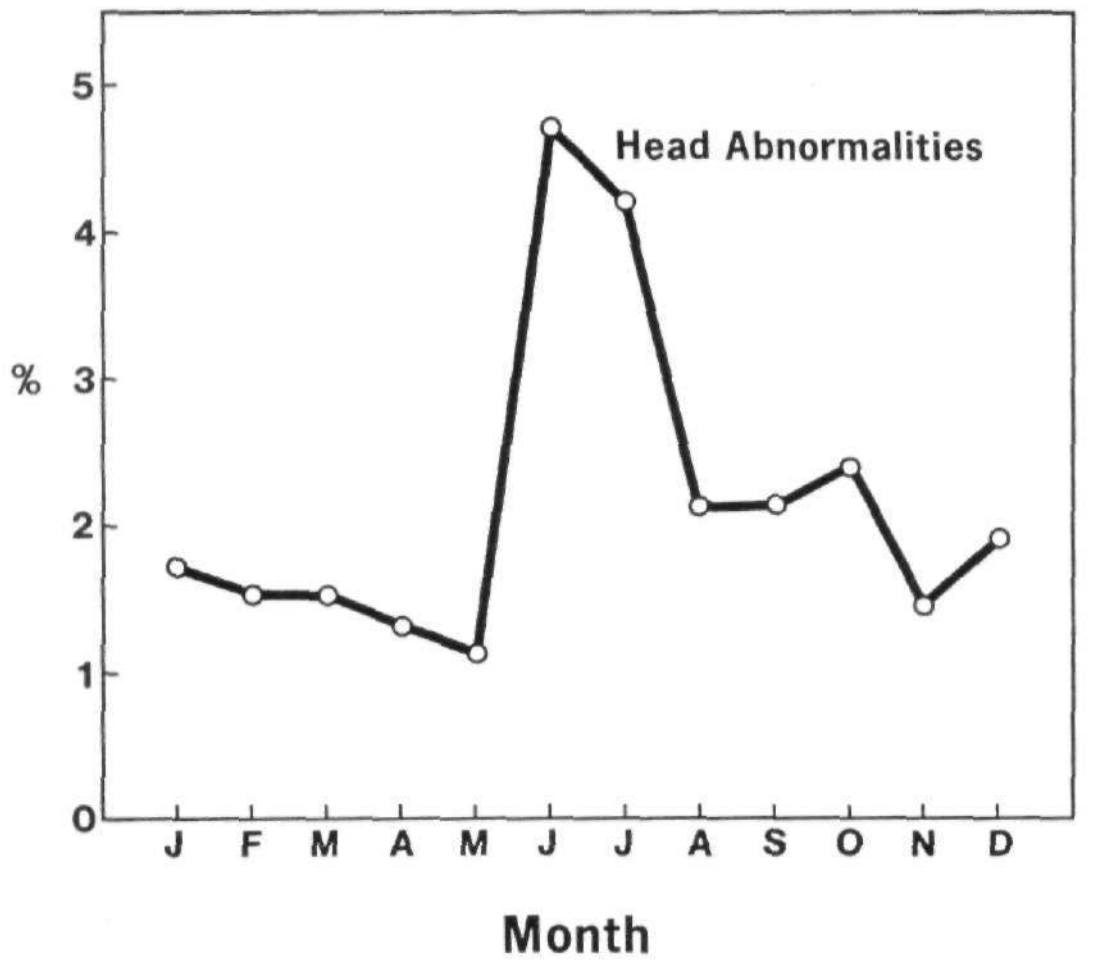


FIGURE 3. Seasonal Variations of Head Abnormalities of the Bovine Semen

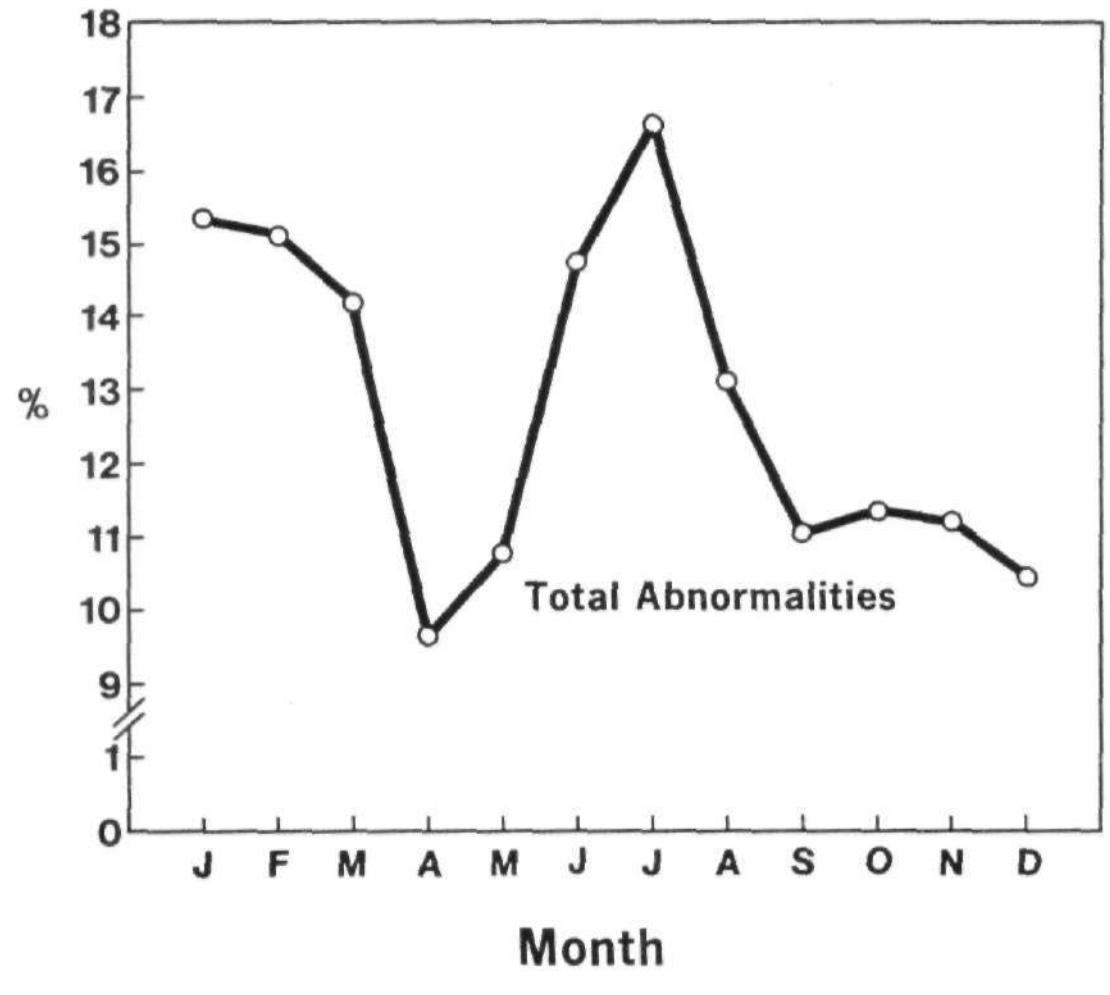


FIGURE 4. Seasonal Variations of Total Abnormalities of the Bovine Semen

Proximal cytoplasmic droplets

A summary of the results is presented in table 10. The mean of proximal cytoplasmic droplets for the winter was 1.96% which differs ($P<0.001$). The mean for fall was 2.36% which does not differ significantly from spring which had a mean of 2.79%. Winter differed from spring ($P<0.01$) and summer from fall ($P<0.02$).

Distal cytoplasmic droplets

A summary is presented in table 11. In this study results did not indicate any significant seasonal variations in the percentage of distal cytoplasmic droplets. The means were 1.54%, 1.90%, 2.33%, 2.14% for winter, summer, spring and fall, respectively.

Tail abnormalities

A summary of the results is presented in table 12.

The highest occurrence of tail abnormalities was during the summer which had a mean of 4.60% and the lowest was during the spring (2.91%). Winter had a mean of 4.29% and fall 3.26%. The results for the four seasons did not differ significantly. The results, even though not significantly different, indicated that there was seasonal variations in the occurrence of tail abnormalities.

Tail-less heads

A summary of the results for tail-less heads is presented in table 13. The highest percentage of tail-less heads occurred during the winter with a mean of 2.74% which differs significantly ($P<0.02$) from the summer mean of 0.87% and from spring ($P<0.02$) which had a mean of 0.93%.

Table 11
1977 Percentage Seasonal Values for Distal Cytoplasmic Droplets in 19 Dairy Bulls

	Winter	Summer	Spring	Fall
N	3	3	3	3
Std. Error	0.44	0.44	0.44	0.44
Mean	1.54[a]	1.90[a]	2.33[a]	2.14[a]

N = number of months
The means are not significantly different (P>0.05)

Table 12
1977 Percentage Seasonal Values for Tail Abnormalities in 19 Dairy Bulls

	Winter	Summer	Spring	Fall
N	3	3	3	3
Std. Error	0.74	0.74	0.74	0.74
Mean	4.29[a]	4.60[a]	2.91[a]	3.26[a]

N = number of months
The means are not significantly different (P>0.05)

Table 13
1977 Percentage Seasonal Values for Tail-Less Heads

	Winter	Summer	Spring	Fall
N	3	3	3	3
Std. Error	0.58	0.58	0.58	0.58
Mean	2.74^{a}	0.87^{b}	0.93^{b}	0.84^{b}

N = number of months
Means with different superscripts are significantly different ($P<0.02$)

Table 14
1977 Percentage Seasonal Values for Total Abnormalities

	Winter	Summer	Spring	Fall
N	3	3	3	3
Std. Error	1.19	1.19	1.19	1.19
Mean	13.67^{a}	14.84^{a}	11.48^{b}	11.21^{b}

N = number of months
Means with different superscripts are significnatly different ($P<0.04$)

Total morphological abnormalities

A summary for total morphological abnormalities is presented in table 14. Summer had highest mean of 14.83% which did not differ significantly from the winter mean of 13.67%. The mean for spring was 11.48% which did not differ from the mean of 11.25% for fall. Spring differed from summer ($P<0.04$) and summer from fall ($P<0.03$).

Discussion

From the results obtained there is no doubt that there are seasonal variations in the morphology of the spermatozoa of the 19 bulls sampled the year round. The results agree with the findings of Hultnas (1959), Wells et al. (1972), Igboeli et al. (1971). All the investigators reported seasonal variations in the bovine sperm morphology.

The months of summer (June, July and August) were the hottest period of the year and there were more total morphological abnormalities during the season than any other season. Specifically there were more proximal cytoplasmic droplets, abnormal tails and heads during the summer than any other season. The explanation for the increased level of the morphological abnormalities during the summer is probably because of the heat experienced by the animals at this period. Lagerlof (1934) was able to alter the normal semen as a result of scrotal insulation which led to the production of abnormal sperm cells because of the resultant testicular degeneration. Scrotal insulation, as done by Lagerlof, imposed heat stress on the testicles. He was able to produce various forms of head morphological

abnormalities. He also demonstrated that with extreme heat stress sperm production stopped. Heat stress may occur naturally as during the summer months. Igboeli et al. (1971) found that during the hot season the Angoni (Shorthorn Zebu bulls) have higher percentages of secondary abnormalities and increased droplets. Meyerhoeffer (1976) observed that after three weeks of exposure of bulls to elevated ambient temperature there was an increase in percentage of aged acrosomes, and after eight weeks of exposure there was a reduction in sperm quality. daSilva et al. (1976) found that the direct exposure of Zebu bulls to temperatures above 30°C during the first three weeks of spermatogenesis led to a decrease in semen quality and high correlations with proportions of primary and secondary abnormalities. Evidence from many earlier investigators were suggestive of seasonal variations in the morphology of the bovine spermatozoa. Environmental temperature has a great influence on the function of the testicles as shown by the works of many investigators. During the hot period of the year there is usually an increase in abnormal sperm production by many bulls. The present investigation is in support of the view that elevated environmental temperature impairs testicular function.

The reason for the observed high incidence of tail abnormalities during the winter is not clear. The high incidence of detached sperm head during the winter might be caused by low temperature exposure of the testes. Cooling of the scrotum of rams, with ice resulted in increased frequency of detached sperm heads in the ejaculate a few days after the cold exposure (Gustafsson and Duchateau, personal communication).

Values for Sperm Morphological Characteristics in Dairy Bulls

There were 44 dairy bulls sampled in this investigation. They ranged in age from 1 year, 1 month to 10 years, 5 months. Not all the bulls were sampled round the year. A record of the sampling per bull is presented in the appendix. The bulls are numbered in the appendix from 1 to 44. All are of the holstein breed and used for AI. The bulls used in this study have an average of 71% conception rate. Bull no. 21 had tail abnormalities which ranged from 4.75% to 45.5% in the course of the investigation. The bull had a mean of 23.52% tail abnormalities for the whole year. Bull no. 26 had proximal droplets which ranged from 15.25% to 30% with a mean of 25.70% for five months. Bull no. 27 was treated for digestive problems in January and at the same time had 18.5% of tail abnormalities. The abnormalities might have been connected with the digestive problems. Bane (1954) working on identical twin bulls with lameness and anorexia noted the production of abnormal heads and droplets which remained high for two years. Burges et al. (1975) observed high percentages of midpiece abnormalities in a bull with ephemeral fever. Bane (1954) stated that any disease, however slight, might lead to production of abnormal sperm cells by the testicle. It is probably that the digestive problems observed in no. 27 were responsible for high percentages of the observed tail abnormalities. There was a rapid recovery by the bull. Bulls no. 21 and 27 were sampled round the year while no. 26 was culled after five months because of a decline in fertility. Bull no. 21 declined in fertility to the lowest level of 50% in the herd. In the determination of the normal values of

morphological abnormalities in the semen all the 44 bulls were used. The removal of bulls no. 21, 26 and 27 would have very little effect on the results. The removal of 25 bulls had little effect. The detailed results for all the dairy bulls used in this investigation are presented in the appendix for Study II.

The mean percent abnormalities found in the bulls during the year 1977 are presented in table 15.

Table 15

Proximal Cytoplasmic Droplets	2.89%
Distal Cytoplasmic Droplets	1.87%
Tail-less Heads	0.93%
Acrosome Abnormalities	0.35%
Tail Abnormalities	3.60%
Middle Piece (coiled, rough, swollen, double)	0.44%
Abaxial Attachment of the Mid-piece	0.18%
Abnormal Sperm Heads	2.12%
Total Abnormalities	12.38%

n=426

Discussion

Lagerlof (1934, 1936) found that the semen of fertile bulls had 10-11% morphologically abnormal spermatozoa. It should be borne in mind that Lagerlof did his studies without the phase contrast microscopy. He used stained smears. Study I of this investigation demonstrated that staining procedures were detrimental to droplets. With particular reference to Williams stain and eosin nigrosin many

droplets were lost during the procedures. For the facilities within his disposal Lagerlof was probably correct but for the techniques now available for semen evaluation his results may not be strictly acceptable for the present time. He stated that pathological sperm in bulls with good fertility should not exceed 17-18%. In this investigation the total abnormalities were 12.38% which is lower than 17%. The bulls could be classified as having good semen with acceptable value. The records of their performance indicate good fertility of an average of 71% conception rate. Blom (1950a) studied 100 fertile Danish bulls and classified sperm abnormalities into primary and secondary types. There was no such classification in this study for the simple reason that there is no scientific basis for such classification (Blom, 1973). Blom found 10.4% of primary abnormalities in the bulls. He further noted that 15% primary sperm abnormalities led to impairment of fertility and was an indication of testicular degeneration or hypoplasia. Primary abnormalities were due to faulty spermatogenesis and the secondary abnormalities occurred after the spermatozoa left the spermatogenic epithelium. He found 20-25% of secondary abnormalities in fertile bulls. By simple addition, a total of at least 30% abnormalities (primary and secondary) could be acceptable for fertile bulls. The value of 12.38% obtained in this study is much lower than that proposed by Blom. Rollinson (1951) obtained a mean of 11.8% abnormal spermatozoa in fertile bulls. His value is slightly lower than the finding in the present investigation. Rollinson had fewer bulls and employed different techniques from those employed in this investigation. Melrose (1970) found 4.6%-10.6% of

primary abnormalities in the semen of normal fertile bulls, while proximal droplets averaged 2-3%. He recommended that primary abnormalities should never exceed 15-20% in bulls with normal fertility. Zemjanis (1970) recommended that abnormal forms should not exceed 10-20% and primary abnormalities should not exceed 10% in acceptable semen. The present investigation had a value within the recommendation of Zemjanis. Rao (1971) in normal bulls found the average proportion of abnormal heads to be 6%, cytoplasmic droplets 2%, middle piece abnormalities 0.8%, tail abnormalities 3.5%. In this investigation abnormal heads were 2.12%, cytoplasmic droplets (proximal and distal) were 2.89% and 1.87%, respectively, middle piece (coiled, rough, swollen, double) 0.44%, while abaxial attachment of the midpiece was 0.18%. However, the total abnormalities Rao found was about 12.30% while in this study it was 12.38% which is about the same as Rao's.

Tissue cells were very few in the bulls examined. This agrees with the observations of Blom (1950a) who classified them as follows: (a) Primitive spermiogenic cells found in cases of severe testicular degeneration (found in centrifuged sediment). (b) Blood cells. Red blood cells seldom found in normal bulls unless an accident has happened during the collecting process. Presence of typical pus cells indicates inflammatory process in the genitals, usually in the vesicular glands or ampulla of ductus deferens for example in brucellosis. (c) Epithelial cells - may be found in normal semen, 1/1000 cells. Characteristic types being large squamous cells from prepuce or canalis urogenitals. (d) Medusa formations - brush

like bodies and detached fragments of the ciliated border covering most of the cells in the efferent tubules of the testes. There are 1/10,000 sperm in normal bulls. The figure may rise to 20/100 sperm cells in centrifuged sperm of bulls with pathological testis-epididymis. This is important in differential diagnosis. If oligospermia is due to an incomplete ejaculation from a normal bull there would be no medusa formations in the centrifugate.

The tissue cells discussed were very rare occurrences in this investigation.

Correlation of Some Morphological Abnormalities to Non-Return Rate

Nineteen bulls were used for this investigation.

The annual mean of the proximal cytoplasmic droplets, tail abnormalities, and head abnormalities were utilized with the latest 0 to 90 day non-return rate to see if there was any correlation between morphological abnormalities and fertility.

Proximal cytoplasmic droplets had a correlation coefficient of -0.472, $P<0.03$. Tail abnormalities had a correlation coefficient of -0.679, $P<0.001$. The head abnormalities were low and within acceptable limits for good fertility. The correlation coefficient of head abnormalities to fertility was -0.245, $P>0.05$.

Correlation of morphological abnormalities to fertility had been a subject of debate with some authorities. Many investigators in the past had convincing evidence that morphologically abnormal spermatozoa when above certain levels led to a decline of fertility or even sterility (Williams et al., 1920; Lagerlof, 1934, 1936; Rollinson,

1951; Hancock, 1955; Bane, 1954, 1959, 1965; Blom, 1959, 1966, 1968, 1976; Saack, R. G., 1968; Rao, 1971; Peet et al., 1976).

There were two bulls of particular interest in this project. No. 21 between January 1977 to December 1977 had tail abnormalities which ranged between 4.75-45.5% with a mean of 23.52% for the year. The interesting thing about this bull is that he was very fertile with an average of about 71% (60-90 day) non-return rate before the onset of the tail abnormalities. With the onset of the tail abnormalities there was a corresponding decline in non-return rate. The bull deteriorated to a 50.9% (60-90 day) non-return rate, the lowest value amongst the bulls examined. He was culled by July, 1978. The second bull of interest with a decline in non-return rate is no. 26. He had between 15.25%-30% of proximal droplets between January and May, 1978. There was a corresponding decline in his non-return rate. He was culled in May of 1977 when the non-return rate was 55%. The illustration with bull no. 21 and 26 demonstrated that morphologically abnormal spermatozoa beyond a certain limit could lead to a decline in fertility. This is in agreement with findings of many workers already cited in this discussion.

It is possible for a bull to have good semen qualities, good spermatozoa morphology and bad performance as regards fertility. Bouters et al. (1974) found that in a boar with apparently normal ejaculated spermatozoa a hundred percent embryonic mortality occurred in all sows bred by the boar. On karyotyping, thirty percent autosomal translocation could be demonstrated in cultured leucocytes. Gustavsson

(1969) working with the Swedish red and white breed of bulls found that the daughters of translocation sires returned to service more often than daughters of normal bulls due to an increased rate of embryonic death. The genetic defect in the bull was neutral from the point of view of selection but was manifested in the daughters of the translocation sires.

Conclusion of Study II

Study II demonstrated that age and season had their influence on sperm morphology in the bovine. It also showed that morphological abnormal spermatozoa beyond a certain limit could lead to a decline in fertility.

CHAPTER VI

GENERAL CONCLUSION

The methodological study demonstrated that buffered formal saline is a good fixative for the bulls' spermatozoa.

Semen fixed in buffered formal saline and kept at a temperature of +4^{o}C could still produce reliable and accurate results for morphological studies at 4 weeks after storage. The live/dead differential staining could also be preserved.

The combination of the phase contrast microscope and the light microscope gave more accurate results than when the light microscope was used alone. In fact, some abnormalities could only be detected with phase microscopy.

Many aspects of the breeding soundness examination could be done in the laboratory and not on the field if spermatozoa were fixed in buffered formal saline and stored at +4^{o}C.

The second aspect of the investigation showed that age had an effect on the bulls' spermiogram with most abnormalities increasing with age.

Season of the year was also important with the summer being the most detrimental to sperm morphology.

Morphologically abnormal spermatozoa could lead to decline in non-return rate as demonstrated by two bulls in this investigation.

The value for total morphologically abnormal spermatozoa for 1977 in the group of 44 dairy bulls examined was 12.38% (See table 15).

Further studies on morphologically abnormal spermatozoa and

infertility are suggestive from the findings in the present investigation. A lot is yet to be done on the Zebu breeds of bulls where very little is still known.

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REFERENCES

Amman, R. P. and Almquist, J. O. (1962a) Reproductive capacity of dairy bulls. VII Morphology of epididymal sperm. J. Dairy Sci. 45, 1516-1526.

Amman, R. P. and Almquist, J. O. (1962b) Reproductive capacity of dairy bulls. VI. Effect of unilateral vasectomy and ejaculation frequency on sperm reserves, aspects of epididymal physiology. J. Reprod. Fert. 3, 260-268.

Asdell, S. A. (1968) Cattle fertility and sterility. VII Properties of the semen. 110-128. Boston. Little, Brown and Comp.

Bane, A. (1954) Sexual functions of bulls in relation to heredity, rearing intensity and somatic conditions. Acta Agric. Scand. IV. 2, 95-208.

Bane, A. and Nicander, L. (1965) Pouch formations by invaginations of the nuclear envelope of bovine and porcine sperm as a sign of disturbed spermiogenesis. Nord. Vet. Med. 17.

Bialy, G. and Smith, V. R. (1958) Influence of seminal vesicular fluid on morphology of bull spermatozoa. J. Dairy Sci. 41, 422-428.

Bialy, G. and Smith, V. R. (1959) Cold shock of epididymal spermatozoa. J. Dairy Sci. 42, 2002.

Bishop, M. W. H. (1970). Aging and reproduction in the male. J. Reprod. Fert. Suppl. 12, 65-87.

Bishop, M. W. H. and Walton, A. (1960) Spermatogenesis and structure of mammalian spermatozoa. In Marshall's *Physiology of Reproduction* (A.S. *Parkes eds.*), 3rd, Ed., Vol. 1, pt. 2, pp. 1-129. Longman's Green. London.

Bishop, M. W. H., Campbell, R. C., Hancock, J. L. and Walton, A. (1954) Semen characteristics and fertility in the bull. J. Agric. Sci. Camb. 44, 227-248.

Blom, E. (1950a) Interpretation of spermatic cytology in bulls. Fert. Steril. 1, 223-238.

Blom, E. (1950b) On the evaluation of bull semen with special reference to its employment for artificial insemination. Thesis Copenhagen.

Blom, E. (1959) A rare sperm abnormality, "Corkscrew - Sperms" associated with sterility in bulls. Nature, Lond. 183, 1280-1281.

Blom, E. (1966) A new sterilizing and hereditary defect (the "Dag defect") located in the bull sperm tail. Nature, Lond. 209, 739-740.

Blom, E. (1968a) A new sperm defect - "pseudo - droplets"- in the middle piece of the bull sperm. Nord. Vet. Med. 20, 279-283.

Blom, E. (1968b) Male reproductive organs; In reproduction in farm animals. E. S. E. Hafez ed. 2nd Ed., pp. 27-37, Lea and Febiger, Philadelphia.

Blom, E. (1972) Ultrastructure of some characteristic sperm defects and a proposal for a new classification of the bull spermiogram. Vet. Bulleten PG. 502, 3993. Nord. Vet. Med. 25, 383-391.

Blom, E., Birch - Andersen, A. (1966) The ultrastructure of a new hereditary sterilizing defect (the "Dag defect") in the bull sperm tail. Proc. 5th Wld. Cong. Fertil. Steril. Stockholm. Excerpta Med. Intern. Congr. Series No. 133, 602-605.

Blom, E. and Christensne, N. O. (1951) Studies on pathological conditions in the testis, epididymis and accessory sex glands in the bull. II Congenital absence of the epididymis, ductus deferens or glandula vesicularis (aplasia segmentalis ductus. Wolfii) in the bull. Royal Vet. and Agric. College, Copenhagen, Year book 1 - 64.

Blom, E., Wolstrup, C. (1976) Zinc as a possible causal factor in the sterilizing sperm tail defect, the "Dag" defect in Jersey bulls. In. Proc. 8th Int. Congr. Anima. Reprod. and A.I. pp. 33, vol. I.

Bouters, R., Bante, P. Spincemaile, J., Vandeplassche, M. (1974) Chromosomes of domestic animals II, chromosomal abnormalities associated with reproductive disorders. Vlaams Diergeneeskundig Tidschrift (1974) 43 no. 2, 85-91, abstr. 3307.

Braton, C. and Salisbury, G. W. (1947) Morphology of spermatozoa from different levels of the reproductive tract of the bull. J. Anim. Sci. 6, 154-160.

Bryan, J. H. D. (1975) An eosin-fast green-naphthol yellow mixture for differential staining of cytologic components in mammalian spermatozoa. Stain Technology Vol. 45, no. 5, pg. 231.

Burges, G. W., Chenoweth, P. J. (1975) Mid-piece abnormalities in bovine semen following experimental and natural cases of bovine ephemeral fever. British Vet. J. 1975, 131 (5) 536-544.

Campbell, R. C., Hancock, J. L. and Shaw, I. G. (1960) Cytological characteristics and fertilizing capacity of bull spermatozoa. J. Agric. Sci. Camb. 55, 91-99.

Coulter, G. H. (1976) Effect of dexamethasone on the incidence of the "crater" defect of bovine sperm. VIII Intern. Congress on Anim. Reprod. and A.I. PG. 60, vol. I.

Crabo, B. and Gustafsson, B. (1964) Distribution of sodium and potassium and its relation to sperm concenteration in the epididymal plasma of the bull. J. Reprod. Fert. 7, 337-345.

Crabo, B., Gustafsson, B., Nicander, L. and Rao, A. R. (1971) Subnormal testicular function in a bull concealed by phagocytosis of abnormal sperm in the efferent ductules. J. Reprod. Fert. 26, 393-396.

Crabo, B. G. and Hunter, A. G. (1975) Sperm maturation and epididymal function. Dept. of Animal Sci., Univ. of Minn., St. Paul, 55108. In Control of Male Fertility. eds. Sciara, J. J., Markland, C., Speidel, J. J. Harper and Row, Hagerstown, Maryland, pg. 2-23.

Cupps, P. T., and Briggs, J. R. (1965) Changes in the epididymis associated with morphological changes in the spermatozoa. J. Dairy Sci. 48, 1241-1244.

Drevius, L. O. (1963) Spiralization in tails of mammalian spermatozoa in hypotonic media. Nature, London. 1973, 1123-1124.

Dott, H. M., Foster, G. C. (1975) Preservation of differential staining of spermatozoa by formal citrate. J. Reprod. Fert. 45, 57-60.

Fraser, A. F. and Wilson, J. C. (1966) Testicular calcinosis in domestic ruminants. Nature, London. 210, 547.

Foote, R. H. (1975) Semen quality from the bull to the freezer, an assessment. Theriogenology 3:219-35.

Gledhill, B. L. (1966) Studies on the DNA content, dry mass, and optical area of bull spermatozoa heads during epididymal maturation. Acta Vet. Scand. 7, 131-142.

Glover, T. D. (1962) The reaction of rabbit spermatozoa to nigrosin eosin following ligation of the epididymis. Int. J. Fert. 7, 1-9.

Glover, T. D. (1969) Some aspects of function in the epididymis. Int. J. Fert. 14, 215-221.

Gombe, S., Norman, C., Mbogo, D. E. (1975) Detachment of acrosomal caps of bulls spermatozoa by coconut fatty acid monoethalomide ethoxylate. Journal of Reprod. Fert. 43, No. 3, 535-537.

Gustafsson, B. (1962) A case of necrospermia in the bull. Int. J. Fert., 7, 356.

Gustafsson, B. (1964) The sodium and potassium content in epididymal plasma of bulls with certain reproductive disturbances. Proc. 5th Int. Cong. Anima. Reprod., Trento, 5, 193-197.

Gustafsson, B. (1965) A case of akinesia of bull sperm associated with a functional disturbance in the epididymis. Nord. Vet. Med. 17, 65-72.

Gustafsson, B. (1966) Luminal contents of the bovine epididymis under conditions of reduced spermatogenesis, luminal blockage and certain sperm abnormalities. Acta. Vet. Scand. 7, Suppl. 17.

Gustafsson, B. (1972) Diagnosis of primary epididymal dysfunction in the bull. VII International Kongress fur Tierische Fortpflanzung, Munchen, Bond.

Gustafsson, B. and Crabo, B. (1971) Some morphological characteristics of bull spermatozoa at different levels of epididymis. Nord. Vet. Med. 23, 114-118.

Gustafsson, B., Crabo, B. and Rao (1971) Two cases of epididymal dysfunction in bulls. Cornell Veterinaria 62-392.

Gustafsson, B., Einarsson, L., Nicander, L., Holtman, M. and Soosaloi, O. (1974) Morphological, physical and chemical examination of epididymal contents and semen in a bull with epididymal dysfunction. Andrologia 6(4):321-331.

Gustafsson and Duchateau (1977) The effect of application of ice on ram scrotum and sperm morphology. Pers. Comm.

Gustavsson, Ingemar. (1969) Cytogenetics distribution and phenotypic effects of a translocation in Swedish cattle. Hereditas 63, 68-169.

Hahn, J., Foote, R. H., and Seidel, G. E. (1969) Quality and freezability of semen from growing and aged dairy bulls. J. Dairy Scil. 52, 1843-1848.

Hancock, J. L. (1955) The disintegration of bulls spermatozoa. Vet. Rec. 67, 825-826.

Hancock, J. L. (1957) The morphology of boar spermatozoa. J. Roy. Microsco. Soc. 76-84, 1957.

Harasmowycz, J., Ball, L., Seidel, G. E. (1976) Evaluation of bovine spermatozoa morphologic features after staining or fixation. Am. J. Vet. Res., Vol. 37, No. 9, 1053-1057.

Hopwood, M. L., Faulkner, L. C. and Gassner, F. X. (1963) Effect of exhaustive ejaculation on composition of bovine semen. J. Dairy Sci. 46, 1409-1415.

Hultnas, C. A. (1959) Studies on variation in mating behaviour and semen picture in young bulls of Swedish Red and White breed and on causes of this variation. Acta. Agric. Scand. Suppl. 6.

Igboeli, G. and Foote, R. H. (1968) Maturation changes in bull epididymal spermatozoa. J. Dairy Sci. 51, 1703-1705.

Igboeli, G. and Rakha, A. M. (1970) Bull testicular and epididymal function after long term vasectomy. J. Anim. Sci. 31, 72-75.

Igboeli, G. and Rakha, A. M. (1971) Seasonal changes in the ejaculate characteristics of Angoni (short horn Zebu) bulls. A. M. Journal of Animal Science 33 No. 3, 651-654.

Kaderli, R., Konig. (1975) Schweizer Archiv fur Tierherkunde 117 (8), 425-437 (De, Fr, en, it).

Knudsen, O. (1954) Cytomorphological investigations into spermiocytogenesis of bulls with normal fertility and bulls with acquired disturbances in spermiogenesis. Acta. Path. Microbiol. Scand. Suppl. 101.

Koefoed-Johnsen and Henning Pedersen. (1971) Further observations on the Dag defect of the tail of the bull spermatozoan. J. Reprod. Fert. 26, 77-83.

Kollicker, A. (1855) Physiologische studies uber die samenflussigkeit. Z. Wiss Zool. 7, 266.

Lagerlof, N. (1934) Researches concerning the morphologic changes in the spermatozoa and in the testicles of sterile or subnormally fertile bulls. (Review by Williams, W. L.) Acta. Path. Microb. Scand. Suppl. 19.

Lagerlof, N. (1936) Sterility Bulls. Vet. Rec. 48, 1159-1170.

Lancaster, M. C. (1956) A survey of pathological changes in the testicles of A.I. Bulls. Proc. 3rd Int. Cong. Anim. Reprod. Cambridge. 2, 71-73.

Lasley, J. F. and Mayer, D. T. (1944) A variable physiological factor necessary for the survival of bull spermatozoa. J. Anim. Sci. 3, 129-135.

Lino, B. F., Braden, A. W. H. and Turnbull, K. E. (1967) Fate of unejaculated spermatozoa. Nature, London. 213, 594-595.

Marc, S., Cohen, Michael, J. C., Mircea, G., Robert, S. H. (1977) The effects of prostaglandins on sperm motility. Fert. Steril. Vol. 28, No. 1, pg. 78-85.

Marshall, C. E. and Hafs, H. D. (1976) Sperm output and quality after PGF2 in bulls. J. Anim. Sci. 43, 296.

Meyerhoeffer, D. C., Wetterman, R. P., Wells, M. E. and Turman, E. J. (1976) Effect of elevated ambient temperature on bulls. J. Anim. Sci. 43, 297-331.

McEntee, K. (1958) Pathological conditions in old bulls with impaired fertility. J. Am. Vet. Med. Ass. 132, 328-331.

McEntee, K. (1959) Histopathology of sterility in the bull testicular lessions. 16th Int. Vet. Congr. 2, 933-934.

McEntee, K. (1970) The male genital system. In pathology of domestic animals by Jubb, K. V. F. and Kennedy, P. C., 2nd ed., Vol. 1, pp. 443-485. Academic Press, New York.

Melrose, D. R. and Laing, J. A. (1970) Fertility and infertility in domestic animals. The characteristics of normal semen. 128-159.

Orgebin-Crist, M. C. (1969) Studies on the function of the epididymis Biol. Reprod. Suppl. 1, 155-175.

Peet, R. L., Micke (1976) The Dag and swollen abaxial mid-piece spermatozoa defects in bulls. Aust. Vet. Journal, Vol. 52, 476-477.

Pursley, G. R. and Herman, H. A. (1950) Some effects of hypertonic and hypotonic solutions on the livability and morphology of bovine spermatozoa. J. Dairy Sci. 33, 220-227.

Rao, A. R. (1971) Changes in the morphology of sperm during their passage through the gential tract in bulls with normal and impaired spermatogenesis. Stockholm thesis.

Rao, C. K. and Hart, G. H. (1948) Morphology of bovine spermatozoa. Am. J. Vet. Res. 9, 117-124.

Raja, C. K. S. V., Mathai, E., Nair, K. P. (1974) Congenital tail abnormalities of spermatozoa in a Jersey bull. Kerala J. Vet. Sci. 5, No. 1, 44-49.

Retief, G. P., Neitz, W. O., McFarlane, I. S. (1971) Observations on the effect of tickborne fever on the spermatogenesis of bulls. J. South Afric. Vet. Med. Assoc., No. 4, 321-325, Vet. Bulletin 42-3777.

Robert, S. J. (1971) Vet. obsterics and genital diseases. Infertility in male animals. 604-611.

Rollinson, D. H. L. (1951) Studies on the abnormal spermatozoa of bull semen III. Br. Vet. J. 107, 451-468.

Roussel, J. D., Stallcup, O. T., Austin, C. R. (1967) Selective phagocytosis of spermatozoa in the epididymis of bulls, rabbits and monkeys. Fert. Steril. 18, 509-516.

Saacke, R. G. (1976). Sperm concentration, the acrosome and agglutination (bull). J. Anim. Sci. 43, 302.

Saacke, R. G., Amman, R. P., Marshall, C. E. (1968) Acrosomal cap abnormalities of sperms from subfertile bulls. J. Anim. Sci. 27, 1391-1400.

Salisbury and Vandemark. (1961) Physiology of reproduction and artificial insemination of cattle. W. H. Freeman and Company. pg. 326-345.

Selivanova, O. A. (1937) The movement and disappearance of the kinoplasmic droplet in spermatozoa of farm animals. A contribution to the question of maturity of spermatozoa. Anim. Breed. Abstr. 7, 180-181.

Setchell, B. P., Scott, T. W., Voglmayr, J. K. and Waites, G. M. H. (1969) Characteristics of testicular spermatozoa and the fluid which transports them into the epididymis. Biol. Reprod. Suppl. 1, 40-66.

Silva da (1976) Influence of high environmental temperature on some semen characteristics of Zebu bull semen VIIIth Inter. Congr. on Anim. Repd. and A.I., pp. 241, vol. I.

Sisson, S. and Grossman, J. D. (1953) The anatomy of the domestic animals. 4th Ed., W. B. Saunders Co.

Swanson, E. W. and Boyd, L. J. (1962) Factors affecting coiled tail spermatozoa in the bull. Am. J. Vet. Res. 23, 300-309.

Vale Filho, V. R., Megal, F., Garcia, O. S. (1976) Mitochondrial sheath defects in spermatozoa of sterile G yr bulls. VIII Inter. Congress on Anim. Reprod. and A.I., pg. 265, Vol. I.

Walters, R. J. (1976) Sperm recovery postmortem. VIII Intern. Congress on Anim. Reprod. and A.I., pg, 275, Vol. 1.

Watson, P. F., Martin, I. C. (1972) Comparison of changes in the acrosomes of deep frozen ram and bull sperm. J. Repd. Fert. 28, 99-101.

Wells, M. E., Awa, O. A. (1971) New techniques for accessing acrosomal characteristics of spermatozoa. J. Dairy Sci. 53, 227-232.

Wells, M. E., Awa, O. A., Jay, L. J., Fancy, S. S. (1971) Effect of sexual rest and frequency of ejaculation on sperm acrosomal morphology. J. Dairy Sci. 54, 526-530.

Webster, W. M. (1932) Bovine steriligy in New Zealand. Aust. Vet. J. 8, 199-222.

White, I. G. and Wales, R. G. (1961) Comparison of epididymal and ejaculated semen of the ram. J. Reprod. Fert. 2, 225-237.

Williams, W. W. (1920) Techniques of collecting semen for laboratory examination with a review of several diseased bulls. Cornell Vet. 10, 87-94.

Wright, P. J. (1974) Detached heads in the ejaculate of a Hereford bull. Aust. Vet. Journal 50, No. 1, 39-40.

Zemjanis, R. (1970) Diagnostics and therapeutic techniques in animal reproduction, collection and evaluation of semen. Ch. 12, 150-155.

APPENDIX A

APPENDIX FOR METHODOLOGICAL STUDIES.
% MEAN VALUES FOR PATHOLOGIC SPERM HEAD AT DAY 0 AND AT A MONTH STUDIED WITH TWO DIFFERENT METHODS

	PATHOLOGIC SPERM HEADS			
BULL NO.	EN0	EN1	WS0	WS1
1	0.8	2.4	1.4	1.8
2	11.4	3	8.8	14.2
3	3.2	2.8	3.6	3
4	3.4	8.0	5.2	6
5	1	2.8	3.2	2.2
6	2.6	1.6	2	2.6
7	3.2	3.6	1.4	1.6
8	2.8	2.2	1.8	1.4
9	5	4.6	1.4	1.4
10	13.4	17.4	8.6	9
11	3	2.4	1.6	1.8
12	0.8	2	1.4	2.2
13	1.4	3.2	2.4	3.4
14	4.8	8.6	3.8	3.6
15	1	1.6	1.2	1.2
16	2.2	2.6	3.4	3
17	3.6	2.8	1.4	1.6
18	1.4	3.4	1.8	1.6
19	4.2	6.2	5.2	4.8
20	1.2	2	2	1.8
21	6.4	3.6	3.6	4.8
22	2	2.2	2.8	2.6
23	1.8	2	1.6	1.8
24	0.8	1.8	1	1.2
25	2.6	3.4	3.2	2.4
26	1.8	1.2	2.2	1.6
27	1.8	5	1.2	1.6
Mean	3.24	3.79	2.86	3.16
SD	3	3.27	2.05	2.81

APPENDIX FOR METHODOLOGICAL STUDIES
% MEAN VALUES FOR ACROSOME ABNORMALITIES AT DAY 0 AND AT A MONTH STUDIED WITH THREE DIFFERENT METHODS

	ACROSOME ABNORMALITIES					
BULL NO.	FSO	FS1	ENO	EN1	WSO	WS1
1	0.25	0.5	-	-	0.25	-
2	0.5	1	0.5	1.25	0.6	-
3	0.75	1	-	0.25	-	1.4
4	3.25	2.25	-	1	0.5	0.5
5	1	1	0.25	-	0.25	-
6	1	1	0.25	0.25	0.5	0.25
7	0.25	0.5	0.5	0.5	0.5	0.25
8	0.25	-	-	-	-	-
9	-	-	0.25	1	0.25	-
10	18.5	20.25	10.25	8.5	6.25	16
11	1.25	1	0.25	0.75	0.75	-
12	0.5	0.5	-	-	-	-
13	0.5	0.75	0.25	0.75	-	0.25
14	3.25	3.25	2.75	3.45	0.5	5
15	0.5	0.5	-	0.4	0.5	0.25
16	0.72	0.5	-	-	-	-
17	1.25	0.75	-	0.6	0.5	-
18	0.25	0.25	0.8	-	-	-
19	0.25	0.25	0.25	0.25	-	-
20	0.5	0.25	-	-	0.5	-
21	-	0.25	-	0.25	-	0.25
22	0.25	0.25	-	0.25	-	-
23	-	-	0.25	0.25	-	0.25
24	0.25	-	-	-	-	0.25
25	-	0.75	-	0.5	0.25	0.75
26	1.25	-	-	0.75	-	-
27	-	0.25	0.25	-	-	-
Mean	1.35	1.37	0.62	0.78	0.45	0.94
SD	3.53	3.83	2	1.69	1.19	3.16

APPENDIX FOR METHOLODIGCAL STUDIES.
% MEAN VALUES FOR PROXIMAL CYTOPLASMIC DROPLETS AT DAY 0
AND AT A MONTH STUDIED WITH THREE DIFFERENT METHODS

	PROXIMAL CYTOPLASMIC DROPLETS					
BULL NO.	FSO	FS1	ENO	EN1	WSO	WS1
1	1.75	2.0	0.25	0.5	0.5	1.8
2	90.5	90.0	70	67.2	48.6	14.2
3	1.75	1.5	2	0.5	1	3
4	3	1.5	5.5	1.25	1.75	6
5	1	0.5	0.75	-	-	2.2
6	3.75	3	2	1.5	0.25	2.6
7	0.5	0.25	2.5	0.25	-	1.6
8	3.75	2.25	1.25	1.5	0.25	1.4
9	0.75	0.25	0.25	0.25	-	1.4
10	7.25	4.5	5	2	1	9
11	1.75	1.5	3	1.25	0.25	1.8
12	0.25	0.25	-	0.25	-	2.2
13	2.5	3	1.25	2	0.25	3.4
14	3.75	1.5	1.75	1	0.5	3.6
15	0.75	1	0.5	-	-	1.2
16	0.75	0.5	2	-	0.6	3
17	1.25	1.5	1.25	1.2	-	1.6
18	2.5	2	1.2	1.25	1	1.6
19	14.75	13.75	8	6	0.5	4.8
20	7.75	7	2.75	2.25	2.25	1.8
21	11.75	8.5	5.5	0.75	0.75	4.8
22	1.25	0.5	0.25	0.25	-	2.6
23	1.25	1.25	0.5	0.25	-	1.8
24	1	1	1	1	0.5	1.2
25	4	4.25	1.75	2	0.75	3.4
26	2	1.75	0.75	0.25	1	1.6
27	17.25	13.25	14	11.5	0.5	1.6
Mean	8.98	6.23	5	3.93	2.3	3.16
SD	17.26	17.23	13.33	12.86	9.27	2.81

Key:
1) FSO = Buffered formol saline on Day 0
2) FS1 = Buffered formol saline at a month
3) ENO = Eosin-Nigrosin on Day 0
4) EN1 = Eosin-Nigrosin at a month
5) WSO = Williams stain on Day 0
6) WS1 = Williams stain at a month

APPENDIX FOR METHOLOGICAL STUDIES.
% MEAN VALUES FOR DISTAL CYTOPLASMIC DROPLETS AT DAY 0 AND AT A MONTH STUDIED WITH THREE DIFFERENT METHODS

	DISTAL CYTOPLASMIC DROPLETS					
BULL NO.	FSO	FS1	ENO	EN1	WSO	WS1
1	0.25	0.25	2.25	0.25	1	0.5
2	-	-	7.25	0.75	5.4	0.5
3	10.25	11	2	4.5	3	0.6
4	11.5	12.25	6	3.75	2.25	4.5
5	1.25	2.5	1	2.75	0.75	-
6	2	4.25	2.75	1	-	1.2
7	-	0.5	11.75	0.25	2.5	0.5
8	5.25	6	1.25	1.75	0.25	1.25
9	0.25	-	0.75	0.75	-	-
10	1.75	3	4.75	0.75	1	-
11	7.5	8	3.5	2.25	-	0.5
12	0.5	0.5	2	1.25	-	-
13	9.25	7	4.25	2.25	0.75	2.25
14	0.75	3.75	1	0.4	1.25	2.5
15	0.5	0.5	-	0.25	-	-
16	2.25	2.5	0.5	1	0.8	0.25
17	-	-	1.25	-	0.5	-
18	2.75	3.5	0.8	2	1.5	-
19	12.25	13.75	5.25	5.25	-	4
20	7.75	8.5	7.25	0.5	1.75	5.25
21	5.5	2	3.25	0.5	1	6.5
22	0.5	1	0.25	0.25	0.5	0.75
23	0.75	0.5	0.25	0.75	0.25	-
24	1.5	1.25	0.5	0.25	0.75	0.5
25	25.25	17.5	3.75	3.5	1.75	5.75
26	1.25	1	1.5	1.5	0.75	-
27	6.5	4.25	3	1.5	0.5	0.75
Mean	4.34	4.27	2.91	1.48	1.04	1.41
SD	5.7	4.76	2.79	1.4	1.19	1.99

APPENDIX FOR METHODOLOGICAL STUDIES.
% MEAN VALUES FOR MIDDLE PIECE ABNORMALITIES (DOUBLE, COILED, ROUGH, SWOLLEN) AT DAY 0 AND AT A MONTH STUDIED WITH THREE DIFFERENT METHODS

	MIDDLE PIECE ABNORMALITIES (DOUBLE, COILED, ROUGH, SWOLLEN)					
BULL NO.	FSO	FS1	ENO	EN1	WSO	WS1
1	1.25	1	-	0.5	1.5	0.25
2	1	0.25	2.25	4.6	1.6	6.25
3	-	0.25	0.25	0.25	0.25	2.4
4	2.25	1.75	1	1.5	1	1.5
5	1.25	1.5	0.25	0.25	0.75	1
6	0.5	1	1	1	0.75	2
7	0.75	0.5	-	-	-	1.25
8	-	0.25	0.5	-	1.75	0.25
9	-	0.25	-	0.25	0.5	0.5
10	0.75	0.5	0.75	2.5	0.5	1.5
11	2	2	1.25	1	2.5	0.5
12	0.75	0.75	-	-	-	-
13	1.25	1.25	0.5	1	0.75	2
14	0.75	0.5	0.25	0.8	4.75	3
15	0.5	-	0.5	0.2	1.25	-
16	0.75	0.25	0.5	0.75	1.4	0.75
17	2.75	2.75	0.5	0.4	-	0.5
18	0.25	0.25	0.5	0.5	0.25	0.5
19	-	0.75	-	3.25	-	3
20	0.5	0.5	0.5	0.25	0.75	0.5
21	3.75	3.5	0.5	2.25	2	0.75
22	0.75	0.75	0.5	-	1	0.5
23	1.25	1.25	0.25	-	0.75	-
24	1.25	1.25	0.5	0.25	-	0.5
25	2.75	2.5	-	0.25	1	-
26	0.25	1.75	0.5	0.75	0.25	1.25
27	0.75	1	0.25	0.5	0.25	2.5
Mean	1.04	1.05	0.48	0.85	0.94	1.23
SD	0.94	0.87	0.48	1.11	1.01	1.36

APPENDIX FOR METHODOLOGICAL STUDIES.
% MEAN VALUES FOR ABAXIAL ATTACHMENT OF THE MIDDLE-PIECE AT DAY 0 AND AT A MONTH STUDIED WITH THREE DIFFERENT METHODS

	ABAXIAL ATTACHMENT OF THE MIDDLE-PIECE					
BULL NO.	FS0	FS1	EN0	EN1	WS0	WS1
1	-	-	-	-	0.75	0.5
2	-	-	-	-	-	-
3	0.25	0.25	-	-	0.25	0.4
4	0.5	0.25	-	-	-	-
5	-	-	-	-	-	-
6	-	-	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	-	-
9	-	-	0.5	-	-	-
10	-	-	-	-	-	0.25
11	0.5	0.25	-	-	-	0.75
12	-	-	-	-	-	-
13	-	-	-	-	-	-
14	-	-	-	-	-	0.25
15	-	-	-	-	-	-
16	-	0.25	-	-	-	-
17	-	-	-	-	-	-
18	-	-	-	-	-	-
19	-	-	-	-	-	-
20	-	-	0.5	-	-	0.25
21	-	-	-	-	-	0.25
22	-	-	-	-	-	-
23	-	-	-	-	-	-
24	-	-	-	-	-	-
25	-	-	-	0.25	-	-
26	-	-	-	-	-	-
27	-	-	-	-	0.25	-
Mean	0.05	0.04	0.04	0.01	0.05	0.10
SD	0.14	0.09	0.13	0.05	0.16	0.19

APPENDIX FOR METHODOLOGICAL STUDIES.
% MEAN VALUES FOR SPERM TAIL ABNORMALITIES AT DAY 0 AND AT A MONTH STUDIED WITH THREE DIFFERENT METHODS

	SPERM TAIL ABNORMALITIES					
BULL NO.	FSO	FS1	ENO	EN1	WSO	WS1
1	2.5	2.25	0.25	1.25	1	1.25
2	4.75	4.25	2.75	5.6	2.8	4.25
3	1.5	1.5	2	2.5	0.5	1.2
4	9.25	9.25	7	8	7.75	6.25
5	33.75	33.75	32.25	40	27.75	39.5
6	4.25	3.75	5	0.75	1	3.2
7	6.75	5	1.75	3.75	3	4.5
8	2.5	2.25	1.25	2.75	2.75	4
9	1.25	1.5	1.25	3.5	2.5	2.75
10	19	18.75	7.25	10.5	9.5	12.5
11	2	2.25	2.25	2.75	3.5	1.25
12	1.25	1.5	0.5	1.25	-	1.5
13	7.25	7	8.25	8.75	3.25	12.5
14	2.75	3	4	6.2	2	3
15	1	1.5	1.5	3.7	0.5	2
16	3.5	3.75	0.75	1.5	1.2	1.5
17	4.5	4.25	2.5	2	3	4.25
18	2.75	2.5	1	1.75	2.75	2.25
19	6	5	6.75	5.25	4	3.5
20	2.5	2	3.75	0.75	1	4
21	27.75	27.75	13.5	29.25	10.75	14.25
22	3	2.75	2.75	2.5	2.5	2
23	4.5	4.5	4.25	2.5	3.5	3.75
24	7.25	7	10.5	10	8.75	9.75
25	14.75	15.5	24.25	28.5	4.25	7
26	4	2.75	4	3.75	1.5	3
27	15.75	3	22	19.75	10.25	13.25
Mean	7.25	6.60	6.42	7.73	4.49	6.23
SD	8.2	8.11	7.94	9.99	5.57	7.75

APPENDIX FOR METHODOLOGICAL STUDIES.
% MEAN VALUES FOR DETACHED NORMAL SPERM HEADS AT DAY 0 AND AT
AT MONTH STUDIED WITH THREE DIFFERENT METHODS

	DETACHED NORMAL SPERM HEADS					
BULL NO.	FSO	FS1	ENO	EN1	WSO	WS1
1	0.5	0.5	0.25	-	0.25	0.5
2	-	-	0.75	5	3.4	2
3	-	0.25	0.75	5.5	2.75	1.2
4	0.5	0.75	-	8	0.25	3.75
5	1.5	1	1	1.5	0.75	1.75
6	6	6.25	11.25	10.5	5.75	6
7	4.25	2	0.5	10	3	11
8	2	1.25	1.5	7.25	-	0.75
9	2.5	2.25	3	12.75	2	10.75
10	4	4.25	2.5	18.25	4.25	6.75
11	1.25	1	-	2.75	0.75	0.5
12	31.5	29.25	34.5	34.25	1.5	8.5
13	4.5	4.	6.75	23.75	2.25	4
14	1	1.5	1	5.2	0.75	3.25
15	0.5	0.25	-	3.2	0.25	0.5
16	0.75	1	0.25	2.5	1.2	-
17	2.25	1.75	0.5	0.8	2.5	1
18	0.25	0.25	1.2	1	4.5	0.75
19	2.75	3.5	3	18.2	2	9.25
20	0.75	0.75	1	2.75	0.75	1
21	1	7.75	6.5	41.75	-	2.25
22	1.25	1	0.75	1.5	0.5	1.75
23	0.25	0.5	2	1.5	--	0.5
24	5	4.75	4.25	14	0.25	8.75
25	1.75	4	7.5	24.5	1	11
26	0.75	0.75	0.25	2	0.75	0.25
27	2.25	2.25	2.5	3.25	6	3
Mean	2.93	3.06	3.46	9.69	1.75	3.73
SD	5.94	5.59	6.79	10.79	1.75	3.76

APPENDIX B

APPENDIX FOR STUDY 2 USED TO STUDY THE EFFECTS OF AGE AND SEASON

PERCENTAGE VALUES OF HEAD ABNORMALITIES IN BULLS SAMPLED THROUGHOUT 1977

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Row Mean
1	7 M.	1.6	0.6	1.2	0.4	0.4	1	2.6	1.8	2.6	0.4	0.6	0.6	1.15
2	8 M.	3.6	2.2	2	0.6	1	8.4	2.4	1.6	0.6	1.4	0.4	0.8	2.08
3	9 M.	1.2	0.8	1	0.8	0.4	1.8	1	0.8	1	2	0.8	1.4	1.08
4	10 M.	0.6	1.4	0.8	0.6	0.6	2	1.4	0.6	0.4	1.6	2	0.8	1.07
5	10 M.	1	0.6	1.2	1	0.6	11.4	3	1.2	1.4	1.6	1.8	2.6	2.28
6	1 Yr.	4.8	2	2.2	4.2	1.8	5.6	2.2	0.4	3	2.4	3.2	5.6	3.12
7	1 Yr. 1 M.	2.4	1.8	1.6	0.4	0.8	1.8	1.6	1	1.2	1.8	0.4	1	1.32
8	1 Yr. 1 M.	0.8	1	1	1	1.2	1.4	1.4	0.4	0.6	3.2	2.2	0.6	1.23
9	1 Yr. 3 M.	0.8	2	0.6	1.4	1.4	10.8	8.4	2.4	3.4	7.6	2.6	3.8	3.77
10	1 Yr. 9 M.	1	1.2	1.8	0.8	0.4	0.8	2.4	1.4	1.6	1.6	0.4	0.6	1.17
11	1 Yr. 9 M.	3.2	2.6	2.	2.2	2	11.8	5.8	5.4	2.8	4.4	3	3.2	4.03
12	1 Yr. 10 M.	1.6	2.2	1.6	2	1	1.4	4.2	2.4	3.6	6.2	2	4.8	2.75
13	1 Yr. 11 M.	2.2	2.6	0.6	1.6	1	9.2	4	0.8	0.8	1	1.4	0.6	2.15
14	2 Yr.	2	2	3.2	1	2	4	12.6	0.4	1.2	1.4	1.4	1.2	2.70
15	2 Yr.	0.8	1.4	2.2	0.8	0.6	2	2.2	0.6	1.6	1	0.8	0.8	1.23
16	2 Yr. 4 M.	1	0.8	1.4	1	3	4.8	7.2	1	4.8	1	1.8	1.4	2.43
17	2 Yr. 5 M.	1.8	1	1.2	2.2	1.2	0.4	1.2	0.8	1.2	1.2	1.2	1.4	1.23
18	2 Yr. 11 M.	0.6	1	0.4	0.8	0.8	1.4	4.4	1.2	1.2	1.6	1	0.4	1.23
19	3 Yr.	1.8	2.4	3.2	2.2	2	9.4	13	17.6	9	4.8	1.4	3.8	5.88
Column Mean		1.73	1.56	1.54	1.32	1.17	4.71	4.26	2.20	2.21	2.43	1.49	1.86	

Overall Mean = 2.21; N = 228

PERCENTAGE OF PROXIMAL CYTOPLASMIC DROPLETS IN BULLS SAMPLED THROUGHOUT 1977.

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Row Mean
1	7 M.	0	1.75	2.75	2	1	2	2.25	2.5	1.5	0	0.75	1	1.46
2	8 M.	1.75	2	3.5	2.5	2.5	1	2	1	1.5	1.75	0.75	1.5	1.81
3	9 M.	0.25	1.5	1.25	0	0	0	0.25	0.75	0	1	0	0.25	0.44
4	10 M.	2.25	1.25	1.75	1.5	1.75	1.25	0.75	0.75	1	1	0.25	1.75	1.27
5	10 M.	0.25	0.25	0	1.5	0.5	0	0.25	0.75	0.5	0.25	0.5	0.25	0.42
6	1 Yr.	7.5	4.75	5.5	11	3.25	4.5	2.25	4.5	3	7.25	6	10.5	5.83
7	1 Yr. 1 M.	2	1.5	1	4.5	2	2.76	2	3	1	4.5	2.75	3.5	2.54
8	1 Yr. 1 M.	1	0	1.5	0	0.25	0	0.25	0.25	0	0.5	0.75	0.75	0.44
9	1 Yr. 3 M.	4.25	1.75	3.5	8.25	11	17.5	11.25	5.25	7.5	11	6.5	5.75	7.79
10	1 Yr. 9 M.	0.25	1	0	1	1	1	0.75	0	1.75	1.5	0.5	0.25	0.75
11	1 Yr. 9 M.	3.5	0.75	3.75	2	2	6.25	5.5	2.5	4.5	4.5	4.5	3.25	3.58
12	1 Yr. 10 M.	3	1.75	4	1	5	8.5	6.5	6.5	5.25	3.75	5.25	4.25	4.56
13	1 Yr. 11 M.	1	2	2.25	2.75	2.5	2	2	2.5	3.25	0.25	1.5	1.5	1.96
14	2 Yr.	2.75	1.5	4.5	2.75	2.5	4.25	4	2.75	2.5	1.75	1.5	2.25	2.75
15	2 Yr.	0.5	0.75	1.25	1.75	1.5	0.5	3.5	0.5	0.75	1.25	0	0.25	1.04
16	2 Yr. 4 M.	0	0.25	0.75	0.25	1.25	0.5	1	0.25	1.5	0.75	2.5	0.75	0.81
17	2 Yr. 5 M.	2.5	3.75	7.5	12.75	3	5.75	6	1.25	6.25	5	2.75	4	5.04
18	2 Yr. 11 M.	0	0.75	1.75	1	0.75	1	2.25	0.25	0	0.75	0.75	0.75	0.83
19	3 Yr.	1.0	4	3.5	6.5	4.25	2	8.25	18.5	3.5	2.5	2.75	4.5	5.10
Column Mean		1.78	1.64	2.63	3.32	2.42	3.20	3.21	2.83	2.38	2.59	2.12	2.47	

Overall mean = 2.55; N = 228

PERCENTAGE OF DISTAL CYTOPLASMIC DROPLETS IN BULLS SAMPLED THROUGHOUT 1977

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Row Mean
1	7 M.	2.75	0	0.5	4.25	3	0	1	0.25	2.25	0.5	0.5	4	1.58
2	8 M.	0	0	0	0.25	2.75	0.5	0.5	--	1.75	0.25	0.75	0	0.56
3	9 M.	0.75	2.25	0.5	0	1.5	0.25	2	--	1	1.75	0.5	0.75	0.94
4	10 M.	0	0	0.5	1	1	2	0.5	0.75	1	2.5	0.25	1.5	0.92
5	10 M.	1	1	1	3.5	2.5	1.25	1	0	6.75	0.5	0	8.25	2.23
6	1 Yr.	0.75	1	0.5	3.5	0.75	4	1.25	0.5	0	0	1	0.75	1.17
7	1 Yr. 1 M.	0.25	0	0.75	2	1.5	0.75	1	0	1	0.25	0.75	0.5	0.73
8	1 Yr. 1 M.	0.5	0	0	0.25	1.25	0.5	1.5	0.5	0.25	0.25	0.25	1.5	0.56
9	1 Yr. 3 M.	0	0	0.25	0.75	3.5	2.75	1.5	1.5	3.25	0	3.5	3.5	1.71
10	1 Yr. 9 M.	1.75	0	0	1.25	1.75	3.25	0.5	0	1.25	4	0	0.25	1.17
11	1 Yr. 9 M.	0.5	1.25	0.5	1.75	1.5	12.5	8	1.75	1.75	5.25	5.25	5.25	3.77
12	1 Yr. 10 M.	0.5	0.75	1.5	1.25	5.75	4.25	4.75	3	6.5	3.25	6.5	5.5	3.63
13	1 Yr. 11 M.	0.75	0.5	41	0.5	0.75	1.5	0.75	0.25	0.75	1.25	1	0	4.08
14	2 Yr.	0.75	0.25	0.5	2.25	1.75	0.75	1	1.75	1.25	5.5	5.25	1.25	1.85
15	2 Yr.	0.75	0.25	0	0.75	0.75	2	2	0.75	0.75	1.5	1.25	0.5	0.94
16	2 Yr. 4 M.	0.25	0	0	0.75	0.75	0.25	0.25	0.25	0	0.25	16.75	0.75	1.69
17	2 Yr. 5 M.	15.25	0.5	0.5	3.25	23.5	5	3.5	0	2.25	6	5.5	6	5.94
18	2 Yr. 11 M.	0	0.5	0	0.25	1	1	1.75	1.25	0.25	1.25	0.5	0.75	0.71
19	3 Yr.	1.25	0.25	1	0.75	0	2	5	13.5	2.75	0.25	3	10.25	3.33
Column Mean		1.46	0.45	2.58	1.49	2.91	2.34	1.99	1.37	1.83	1.82	2.76	2.70	

Overall mean = 1.97; N = 228

PERCENTAGE OF TAIL ABNORMALITIES IN BULLS SAMPLED THROUGHOUT 1977

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Row Mean
1	7 M.	2.75	1.5	1.25	1.5	0.25	0	0	0.75	0.75	1	1.25	0.75	0.98
2	8 M.	5.5	0	8.75	1.5	2.75	2.25	2.25	3.25	2	1.25	2.5	2.5	2.88
3	9 M.	1.75	5.25	1.5	0.25	1	1.25	0.5	1.5	0.5	2.25	1	2	1.56
4	10 M.	7	5	4	3	2.75	0.5	2.25	3.75	0.25	0.75	1.25	1.5	2.67
5	10 M.	4.5	4.5	2.5	1.5	1	1	2	1.5	1.75	0.75	1.5	1	1.96
6	1 Yr.	5.25	8.25	3.75	5	2.75	4.25	3.75	3.5	2.75	3.75	3.5	1.25	3.98
7	1 Yr. 1 M.	1.75	2.5	1.75	0.25	0	0	0.5	1	1	0.75	1.25	0.5	0.94
8	1 Yr. 1 M.	5	2.5	4.75	1.25	0.75	0.25	0.25	1.25	1.25	6.25	0.75	1	2.10
9	1 Yr. 3 M.	4.25	11.25	4	1	3.5	2.25	6.5	1.25	0.75	1.5	2	1.25	3.29
10	1 Yr. 9 M.	1	4.5	1	1.5	0.75	1.25	4	1	1.25	1.25	1	2.25	1.73
11	1 Yr. 9 M.	7.75	9.75	5	2.75	4.5	3.5	19.25	3.25	2.25	7.5	6.5	3.25	6.27
12	1 Yr. 10 M.	4.75	16	6	4.25	26.25	29.5	45.5	45.25	38.25	19.5	30	17	23.52
13	1 Yr. 11 M.	10	3.75	2.25	1.5	0	0.5	1.25	1.5	1	0.75	0.5	2.75	2.15
14	2 Yr.	18.5	2.5	1.75	1.25	0	0.5	1	0.25	0	1	0.75	0.75	2.35
15	2 Yr.	3.75	4.25	4.25	5.25	1.75	1.75	6.5	14.75	1.5	1.75	1.5	2.75	4.15
16	2 Yr. 4 M.	0.75	9	6.75	1.25	3.5	0.75	1.25	0.75	0.25	1.5	1.25	1	2.33
17	2 Yr. 5 M.	5	9.5	5.5	1	0.25	2	2	12.75	0.5	2.25	2.75	1.75	3.77
18	2 Yr. 11 M.	0.75	2.5	1.75	0.25	0.5	0.5	0.75	0.5	0.75	0.25	2.25	1.75	1.04
19	3 Yr.	2.25	3.5	11.25	1.5	0.25	0.75	8.5	3.5	3.5	1.25	9	1.25	3.88
Column Mean		4.86	5.58	4.09	1.88	2.76	2.78	5.68	5.33	3.17	2.91	3.71	2.43	

Overall mean = 3.77; N - 228

PERCENTAGE OF TAIL-LESS HEADS IN BULLS SAMPLED THROUGHOUT 1977

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Row Mean
1	7 M.	3.25	0.5	1	0.5	0.25	0.25	0.25	0.5	0	0	0.5	0.5	0.63
2	8 M.	1.5	1.5	1.25	1.25	1	0	0	0.25	0	0.25	0.25	--	0.60
3	9 M.	1.5	0.5	0.5	0.75	0	1	0.25	0.5	0.5	0	0	0.75	0.52
4	10 M.	1.75	3.25	0.5	0	0.25	0.25	0.75	0	0.5	0.5	0.5	0.5	0.73
5	10 M.	6	6	2.5	0.5	0.5	0	0	0.75	0.25	0	1.5	0.75	1.56
6	1 Yr.	6	7.5	4	3.25	2.25	2.75	1.75	0.25	0.5	2.75	3.75	2.5	3.10
7	1 Yr. 1 M.	2.25	3	0.5	0	0	1	0.5	0.25	0	0	0.25	0.25	0.67
8	1 Yr. 1 M.	12.25	13.75	1.25	0.5	0.75	0.75	1.5	1	0.75	0.25	1.25	0.25	2.85
9	1 Yr. 3 M.	3	7	3	1.25	1.5	0.75	2.75	0.5	1	2	1.25	0	2.00
10	1 Yr. 9 M.	0.5	2.75	1	0	0.5	1	0.25	0	0.25	0.75	0.75	0	0.65
11	1 Yr. 9 M.	1.75	0.5	0.75	0	0.25	1.5	0.5	0.5	0.5	0	0.5	0.5	0.60
12	1 Yr. 10 M.	3	10.75	2.5	0.25	5.25	2.75	2.25	4	7	2.5	1.75	1.75	3.65
13	1 Yr. 11 M.	0.5	1.5	0.5	0	0.25	0.25	0	0	0.5	0.25	1.25	0	0.40
14	2 Yr.	1.5	6.25	1.75	0	0	0.25	1	--	0.25	2	0.25	0.25	1.13
15	2 Yr.	2.25	5	0.5	0	0	0.25	0.5	0	0.25	0.75	0.5	--	0.83
16	2 Yr. 4 M.	0.75	1	1.25	0	0.25	0.75	0.75	0	0.25	0.25	0.5	0.5	0.52
17	2 Yr. 5 M.	0.75	2.75	0.5	0.75	1.75	1	0.25	0.75	0.25	0.25	0.25	0	0.77
18	2 Yr. 11 M.	12.75	3	1.75	0.75	0	0	0.25	0	0.25	0.25	0.5	0.5	1.67
19	3 Yr.	4.25	3.75	2.5	0.75	0	3	2	7	6.25	1.25	0	0	2.56
Column Mean		3.45	4.22	1.45	0.55	0.78	0.92	0.82	0.86	1.01	0.75	0.76	0.54	

Overall Mean = 1.34; N = 228

PERCENTAGE FOR TOTAL MORPHOLOGICAL ABNORMALITIES IN BULLS SAMPLED THROUGHOUT 1977

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Row Mean
1	7 M.	9.75	5.35	7.20	9.15	4.90	4	6.35	6.8	7.6	2.1	3.85	6.85	6.16
2	8 M.	15.35	23.2	16.50	9.60	11.50	13.15	7.90	7.35	7.6	6.4	3.15	5.05	10.56
3	9 M.	5.45	11.3	5	2.80	3.15	5.55	4.25	3.55	3.0	8.75	3.05	5.90	5.15
4	10 M.	13.6	12.65	8.8	6.10	6.60	6.0	5.90	5.85	3.65	6.85	6	6.30	7.36
5	10 M.	13.0	12.60	9.45	8.50	5.60	14.9	7	4.7	10.9	3.60	5.55	13.35	9.10
6	1 Yr.	24.8	24.75	17.7	30.45	11.55	22.10	12.2	9.15	10.25	17.9	18.45	21.35	18.39
7	1 Yr. 1 M.	9.65	9.80	7.1	7.4	4.55	6.30	6.85	6.00	4.70	7.8	5.9	5.75	6.82
8	1 Yr. 1 M.	20.05	17.25	8.75	3.75	4.45	3.65	5.15	3.40	3.1	10.95	5.45	4.35	7.53
9	1 Yr. 3 M.	12.80	22.25	11.35	13.15	21.15	34.55	30.40	10.9	16.15	22.4	16.85	14.30	18.85
10	1 Yr. 9 M.	26.5	9.70	23.05	5.55	5.65	8.80	8.65	2.65	6.35	9.85	4.15	3.85	9.56
11	1 Yr. 9 M.	17.45	16.35	14.00	9.45	10.5	36.3	41.05	14.65	12.05	24.15	20.75	16.95	19.47
12	1 Yr. 10 M.	13.10	32.30	17.6	10.50	43.5	46.9	63.7	61.65	61.60	35.95	44.25	33.8	38.73
13	1 Yr. 11 M.	15.45	10.85	46.6	6.35	4.75	14.45	8.25	5.55	6.30	4.25	6.4	5.85	11.25
14	2 Yr.	25.50	13.0	12.20	7.25	6.25	10.25	19.6	5.4	5.20	11.9	6.9	6.45	10.83
15	2 Yr	9.05	12.65	8.20	10.05	5.60	7.25	15.2	16.85	5.60	7.25	4.55	4.55	8.90
16	2 Yr. 4 M.	5.0	11.30	11.40	3.50	9.0	8.80	10.95	2.75	7.05	4.75	23.8	5.4	8.64
17	2 Yr. 5 M.	25.80	18.0	16.20	22.45	34.45	14.90	17.2	16.10	10.95	15.95	12.7	13.65	18.20
18	2 Yr. 11 M.	16.35	8.75	6.4	3.30	4.05	4.15	9.65	3.95	2.45	4.6	5	5.15	6.15
19	3 Yr.	14.3	15.15	21.45	12.2	6.75	18.15	37.75	60.35	25.50	10.8	16.15	20.3	21.57
Column Mean		15.42	15.11	14.16	9.55	10.73	14.74	16.74	13.03	11.05	11.38	11.21	10.48	

Overall Mean = 12.80; SD = 2.40; N - 228

APPENDIX C

PERCENTAGE OF ABNORMAL SPERMATOZOA IN THE YOUNGEST BULLS (PREPUBERTAL) SAMPLED FROM JUNE TO DECEMBER OF 1977

Head Morphological Abnormalities

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	2.6	2.6	2.6	1.8	1.4	1.2	1.8
2	8 M	--	--	--	--	--	3.2	6.4	1.2	0.6	0.6	1.8	2
3	9 M	--	--	--	--	--	8.4	2	2.4	1.4	0.6	0.6	1.2
4	10 M	--	--	--	--	--	3.4	5.8	1.2	1.4	0.8	1.4	1
5	10 M	--	--	--	--	--	2.6	4.4	3.6	1.4	1.4	1.6	2.6
6	1 Yr	--	--	--	--	--	1.4	0.6	1	0.8	0.4	1.2	0.6
Mean		--	--	--	--	--	3.60	3.63	2	1.23	0.87	1.30	1.53
S/D		--	--	--	--	--	2.45	2.27	1.04	0.45	0.43	0.41	0.73
n		--	--	--	--	--	6	6	6	6	6	6	6

Acrosome Abnormalities

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	--	0.5	0.5	--	0.5	0.5	0.25
2	8 M	--	--	--	--	--	--	--	0.25	--	0.75	0.25	0.25
3	9 M	--	--	--	--	--	1	--	--	--	0.5	0.2	--
4	10 M	--	--	--	--	--	--	0.5	0.25	--	1	0.75	--
5	10 M	--	--	--	--	--	0.5	1.25	--	0.25	0.5	0.5	0.25
6	1 Yr	--	--	--	--	--	--	--	0.25	--	0.25	0.5	0.5
Mean		--	--	--	--	--	0.25	0.38	0.21	0.04	0.58	0.45	0.21
S/D		--	--	--	--	--	0.42	0.49	0.19	0.10	0.26	0.20	0.19
n		--	--	--	--	--	6	6	6	6	6	6	6

Proximal Cytoplasmic Droplets

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	2.75	4.25	2.5	2	2.75	2.25	1.75
2	8 M	--	--	--	--	--	0.75	1.25	0.25	0.5	1	0.25	0.5
3	9 M	--	--	--	--	--	1.75	1	2.5	1.25	1	1.4	3.25
4	10 M	--	--	--	--	--	5.5	3	3.5	1.75	4.5	3	1.75
5	10 M	--	--	--	--	--	7	5	3	2.25	1.75	3	2
6	1 Yr	--	--	--	--	--	1.75	4	1.75	1.25	0.25	1.75	0.75
Mean		--	--	--	--	--	3.25	3.08	2.25	1.5	1.88	1.94	1.67
S/D		--	--	--	--	--	2.45	1.65	1.14	0.63	1.54	1.05	0.98
n		--	--	--	--	--	6	6	6	6	6	6	6

Distal Cytoplasmic Droplets

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	1	1.25	0.25	1	0.5	2	0.5
2	8 M	--	--	--	--	--	1.25	0.5	--	--	1	1.5	0.75
3	9 M	--	--	--	--	--	1	3.5	0.5	0.5	1.5	0.8	0.5
4	10 M	--	--	--	--	--	2.75	1.25	1.25	2.5	1.5	1.25	1.75
5	10 M	--	--	--	--	--	0.5	2	--	1.75	2	0.75	2
6	1 Yr	--	--	--	--	--	0.25	1.5	1.75	0.5	1.5	1	5
Mean		--	--	--	--	--	1.13	1.67	0.63	1.04	1.33	1.22	1.75
S/D		--	--	--	--	--	0.88	1.02	0.72	0.93	0.52	0.48	1.72
n		--	--	--	--	--	6	6	6	6	6	6	6

Middle Piece Abnormalities
(viz: Swollen, Double, Rough, Coiled)

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	--	0.75	0.25	0.5	--	0.25	0.75
2	8 M	--	--	--	--	--	1.25	--	--	0.25	--	0.25	0.5
3	9 M	--	--	--	--	--	0.5	--	0.25	--	0.25	0.2	0.5
4	10 M	--	--	--	--	--	--	0.25	--	--	1	1.25	--
5	10 M	--	--	--	--	--	--	1.75	--	0.25	1	--	--
6	1 Yr	--	--	--	--	--	--	--	0.25	0.25	0.5	0.25	0.25
Mean		--	--	--	--	--	0.29	0.46	0.13	0.21	0.46	0.37	0.33
S/D		--	--	--	--	--	0.51	0.70	0.41	0.19	0.46	0.44	0.30
n		--	--	--	--	--	6	6	6	6	6	6	6

Abaxial Attachment of The Middle Piece

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	--	--	--	--	--	--	--
2	8 M	--	--	--	--	--	--	--	--	--	--	--	--
3	9 M	--	--	--	--	--	--	0.5	--	--	--	--	--
4	10 M	--	--	--	--	--	--	--	--	--	--	--	--
5	10 M	--	--	--	--	--	--	--	--	--	--	--	--
6	1 Yr	--	--	--	--	--	--	--	--	--	--	--	0.25
Mean		--	--	--	--	--	0	0.08	0	0	0	0	0.04
S/D		--	--	--	--	--	0	0.20	0	0	0	0	0.10
n		--	--	--	--	--	6	6	6	6	6	6	6

Tail Abnormalities

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	2	1	0.25	0.75	1.25	1	2
2	8 M	--	--	--	--	--	0.5	0.5	3	0.25	1.5	0.25	0.75
3	9 M	--	--	--	--	--	2	2.75	1.75	0.5	1.75	2.0	1.25
4	10 M	--	--	--	--	--	1.5	1.	2.75	2.5	0.75	3	1.5
5	10 M	--	--	--	--	--	0.5	0.75	2.5	0.75	0.5	0.25	0.25
6	1 Yr	--	--	--	--	--	0.75	2.5	1.75	2	1.5	2.25	0.75
Mean		--	--	--	--	--	1.21	1.42	2	1.13	1.21	1.46	1.08
S/D		--	--	--	--	--	0.71	0.96	1	0.90	0.49	1.13	0.63
n		--	--	--	--	--	6	6	6	6	6	6	6

Tail-less Heads

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	0.25	0.25	0.25	0.25	--	0.5	0.5
2	8 M	--	--	--	--	--	1	0.25	--	0.5	0.25	0.5	1
3	9 M	--	--	--	--	--	--	0.25	0.5	0.5	0.5	0.6	--
4	10 M	--	--	--	--	--	--	--	--	0.25	0.25	--	0.25
5	10 M	--	--	--	--	--	0.5	--	0.25	--	--	0.5	0.25
6	1 Yr	--	--	--	--	--	1.5	0.25	0.25	1	0.25	0.75	0.5
Mean		--	--	--	--	--	0.54	0.17	0.21	0.42	0.21	0.48	0.42
S/D		--	--	--	--	--	0.60	0.13	0.19	0.34	0.19	0.25	0.34
n		--	--	--	--	--	6	6	6	6	6	6	6

APPENDIX D

VALUES FOR SPERM MORPHOLOGICAL CHARACTERISTICS IN DAIRY BULLS

Head Morphological Abnormalities

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	2.6	2.6	2.6	1.8	1.4	1.2	1.8
2	8 M	--	--	--	--	--	3.2	6.4	1.2	0.6	0.6	1.8	2
3	9 M	--	--	--	--	--	8.4	2	2.4	1.4	0.6	0.6	1.2
4	10 M	--	--	--	--	--	3.4	5.8	1.2	1.4	0.8	1.4	1
5	10 M	--	--	--	--	--	2.6	4.4	3.6	1.4	1.4	1.6	2.6
6	1 Yr	--	--	--	--	--	1.4	0.6	1	0.8	0.4	1.2	0.6
7	1 Yr 1 M	1.6	0.6	1.2	0.4	0.4	1	2.6	1.8	2.6	0.4	0.6	0.6
8	1 Yr 1 M	3.6	2.2	2	0.6	1	8.4	2.4	1.6	0.6	1.4	0.4	0.8
9	1 Yr 3 M	1.2	0.8	1	0.8	0.4	1.8	1	0.8	1	2	0.8	1.4
10	1 Yr 9 M	0.6	1.4	0.8	0.6	0.6	2	1.4	0.6	0.4	1.6	2	0.8
11	1 Yr 9 M	1	0.6	1.2	1	0.6	11.4	3	1.2	1.4	1.6	1.8	2.6
12	1 Yr 10 M	4.8	2	2.2	4.2	1.8	5.6	2.2	0.4	3	2.4	3.2	5.6
13	1 Yr 11 M	2.4	1.8	1.6	0.4	0.8	1.8	1.6	1	1.2	1.8	0.4	1
14	2 Yr	0.8	1	1	1	1.2	1.4	1.4	0.4	0.6	3.2	2.2	0.6
15	2 Yr	2.2	1.8	2	2.2	--	1.6	2.8	4.2	2.8	2.8	1.8	2.2
16	2 Yr 4 M	0.8	2	0.6	1.4	1.4	10.8	8.4	2.4	3.4	7.6	2.6	3.8
17	2 Yr 5 M	1	--	--	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1	1.2	1.8	0.8	0.4	0.8	2.4	1.4	1.6	1.6	0.4	0.6
19	3 Yr	--	--	2	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	3.2	2.6	2	2.2	2	11.8	5.8	5.4	2.8	4.4	3	3.2
21	4 Yr 6 M	1.6	2.2	1.6	2	1	1.4	4.2	2.4	3.6	6.2	2	4.8
22	4 Yr 6 M	--	--	--	--	--	3.4	1.6	0.4	1.8	1.6	3.8	0.6
23	4 Yr 11 M	--	--	1	--	--	4.6	3.2	0.2	1.6	2.4	0.4	0.8
24	5 Yr	4	2.6	1.4	--	--	17.4	1.2	7	5.8	4.6	1.2	1.6
25	5 Yr	2.2	2.6	0.6	1.6	1	9.2	4	0.8	0.8	1	1.4	0.6
26	5 Yr 1 M	1.2	2.4	1.4	1	3.2	--	--	--	--	--	--	--
27	5 Yr 2 M	2	2	3.2	1	2	4	12.6	0.4	1.2	1.4	1.4	1.2

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
28	5 Yr 3 M	0.8	1.4	2.2	0.8	0.6	2	2.2	0.6	1.6	1	0.8	0.8
29	5 Yr 4 M	--	--	--	--	--	2.2	3.	0.6	1	1.4	1.2	2.2
30	5 Yr 8 M	1	0.8	1.4	1	3	4.8	7.2	1	4.8	1	1.8	1.4
31	5 Yr 9 M	1.8	1	1.2	2.2	1.2	0.4	1.2	0.8	1.2	1.2	1.2	1.4
32	5 Yr 11 M	1.4	2.2	2.6	0.8	--	6	6.2	2.2	2.2	3	1.6	1.4
33	6 Yr	0.8	0.6	1.6	1.8	--	4.8	1.2	1	1.2	2.6	0.6	1.2
34	6 Yr 2 M	1.8	1	0.8	1.6	--	--	--	0.6	2.4	3	0.8	2
35	6 Yr 2 M	1.6	5.8	--	0.6	0.6	1.4	1.4	0.4	0.8	--	--	--
36	6 Yr 9 M	4.6	1.2	3.6	4.8	2	2.8	15.6	4.2	5.5	--	--	--
37	6 Yr 10 M	1	1.2	--	0.8	0.4	0.4	1.2	0.4	1	0.6	0.4	1.2
38	6 Yr 11 M	--	--	--	--	--	18.4	4.4	0.8	2.2	5.6	1	1
39	7 Yr	0.6	1	0.4	0.8	0.8	1.4	4.4	1.2	1.2	1.6	1	0.4
40	7 Yr 1 M	--	--	--	--	--	3	0.4	0.4	1.8	1.6	0.4	0.6
41	7 Yr 3 M	1	1.6	1.4	--	1	2.8	1.2	1	0.4	0.6	1.4	4.8
42	7 Yr 9 M	4.2	--	1.8	1.4	1.2	2	1.8	0.6	1.8	1.8	1	1.8
43	8 Yr 3 M	1.8	2.4	3.2	2.2	2	9.4	13	17.6	9	4.8	1.4	3.8
44	10 Yr	2.6	3.6	--	0.6	0.8	2.4	0.6	2.2	1	1.2	1.8	1.2
Mean		1.88	1.79	1.63	1.40	1.21	4.61	3.72	1.95	2.02	2.16	1.37	1.72
S/D		1.21	1.06	0.79	1.04	0.77	4.41	3.5	2.91	1.70	1.68	0.81	1.30
n		32	30	30	29	26	40	40	41	41	39	39	39

Overall mean for all the bulls sampled in 1977: 2.12%
SD: 1.01
n: 426

Acrosome Abnormalities

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	--	0.5	0.5	--	0.5	0.5	0.25
2	8 M	--	--	--	--	--	--	--	0.25	--	0.75	0.25	0.25
3	9 M	--	--	--	--	--	1	--	--	--	0.5	0.2	--
4	10 M	--	--	--	--	--	--	0.5	0.25	--	1	0.75	--
5	10 M	--	--	--	--	--	0.5	1.25	--	0.25	0.5	0.5	0.25
6	1 Yr	--	--	--	--	--	--	--	0.25	--	0.25	0.5	0.5
7	1 Yr 1 M	1.0	--	--	--	--	0.5	0.25	1	0.25	--	0.25	--
8	1 Yr 1 M	0.25	--	--	0.25	0.5	0.25	--	0.75	--	0.25	0.25	--
9	1 Yr 3 M	--	0.5	--	0.5	--	0.5	--	--	--	0.25	0.25	0.5
10	1 Yr 9 M	0.75	--	--	--	0.25	--	0.25	--	--	--	1	--
11	1 Yr 9 M	--	--	1.75	0.5	--	0.5	0.25	--	0.25	--	--	0.5
12	1 Yr 10 M	--	--	--	0.5	--	0.25	--	--	0.5	0.25	--	--
13	1 Yr 11 M	0.5	1	0.75	--	--	--	0.5	0.25	0.5	0.5	0.25	--
14	2 Yr	--	--	--	0.5	--	--	0.25	--	0.25	0.5	--	0.25
15	2 Yr	0.5	--	1	--	--	--	--	--	--	0.75	0.5	0.25
16	2 Yr 4 M	0.5	0.25	--	--	--	0.25	--	--	--	0.25	0.75	--
17	2 Yr 5 M	0.75	--	--	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	0.75	0.25	0.25	0.25	--	0.25	0.75	0.25	--	0.25	0.75	0.25
19	3 Yr	--	--	--	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	0.25	0.5	1.25	0.75	0.25	0.25	0.75	1	0.25	0.75	1	1.25
21	4 Yr 6 M	0.25	--	0.5	1.5	--	--	0.5	0.25	0.25	--	0.5	0.25
22	4 Yr 6 M	--	--	--	--	--	--	--	--	1	0.25	0.5	--
23	4 Yr 11 M	--	--	0.5	--	--	0.25	--	0.25	--	--	1.25	0.5
24	5 Yr	1	1	0.25	--	--	1.25	0.75	0.25	--	--	--	0.25
25	5 Yr	1	0.5	--	--	--	--	0.25	0.5	--	0.25	0.75	--
26	5 Yr 1 M	--	--	--	0.25	0.5	--	--	--	--	--	--	--
27	5 Yr 2 M	--	--	--	--	--	--	--	0.25	--	0.25	0.75	0.75

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
28	5 Yr 3 M	0.5	0.75	--	0.25	0.5	0.25	--	--	0.75	0.25	0.25	--
29	5 Yr 4 M	--	--	--	--	--	0.25	0.5	--	--	0.5	0.25	--
30	5 Yr 8 M	0.5	--	0.25	--	0.25	1.25	--	0.5	0.25	0.75	0.75	0.5
31	5 Yr 9 M	0.5	0.5	0.25	1.5	--	0.25	1.75	0.25	0.5	0.25	--	--
32	5 Yr 11 M	0.75	--	0.5	--	--	--	--	--	0.5	--	--	0.25
33	6 Yr	--	--	--	--	--	--	--	--	--	0.5	--	--
34	6 Yr 2 M	--	0.75	0.25	--	--	--	--	0.75	--	0.5	0.25	0.5
35	6 Yr 2 M	--	--	--	--	--	--	--	--	0.5	--	--	--
36	6 Yr 9 M	--	--	--	22.5	--	0.75	--	--	--	--	--	--
37	6 Yr 10 M	--	0.75	--	--	--	--	--	0.25	--	--	0.25	--
38	6 Yr 11 M	--	--	--	--	--	1	--	--	--	--	--	--
39	7 Yr	0.5	--	--	--	0.25	--	--	0.5	--	--	--	0.5
40	7 Yr 1 M	--	--	--	--	--	--	--	--	0.5	--	0.25	--
41	7 Yr 3 M	--	--	--	--	--	--	0.5	0.5	--	--	0.25	0.4
42	7 Yr 9 M	3.5	--	1	0.5	--	0.25	0.75	0.25	--	1	1.25	0.25
43	8 Yr 3 M	2.25	--	--	0.25	--	0.5	--	0.25	--	0.25	--	0.25
44	10 Yr	1	1.75	--	2	1	1	0.5	0.5	0.5	0.25	0.5	1.25
Mean		0.53	0.28	0.28	1.10	0.13	0.28	0.27	0.24	0.17	0.31	0.40	0.25
S/D		0.73	0.43	0.45	4.15	0.25	0.37	0.39	0.28	0.25	0.29	0.36	0.32
n		32	30	30	29	26	40	40	41	41	39	39	39

Overall mean for all the bulls sampled in 1977: 0.35%
SD: 0.26
n: 426

Proximal Cytoplasmic Droplets

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct	Nov.	Dec.
1	7 M	--	--	--	--	--	2.75	4.25	2.5	2	2.75	2.25	1.75
2	8 M	--	--	--	--	--	0.75	1.25	0.25	0.5	1	0.25	0.5
3	9 M	--	--	--	--	--	1.75	1	2.5	1.25	1	1.4	3.25
4	10 M	--	--	--	--	--	5.5	3	3.5	1.75	4.5	3	1.75
5	10 M	--	--	--	--	--	7	5	3	2.25	1.75	3	2
6	1 Yr	--	--	--	--	--	1.75	4	1.75	1.25	0.25	1.75	0.75
7	1 Yr 1 M	--	1.75	2.75	2	1	2	2.25	2.5	1.5	--	0.75	1
8	1 Yr 1 M	1.75	2	3.5	2.5	2.5	1	2	1	1.5	1.75	0.75	1.5
9	1 Yr 3 M	0.25	1.5	1.25	--	--	--	0.25	0.75	--	1	--	0.25
10	1 Yr 9 M	2.25	1.25	1.75	1.5	1.75	1.25	0.75	0.75	1	1	0.25	1.75
11	1 Yr 9 M	0.25	0.25	--	1.5	0.5	--	0.25	0.75	0.5	0.25	0.5	0.25
12	1 Yr 10 M	7.5	4.75	5.5	11	3.25	4.5	2.25	4.5	3	7.25	6	10.5
13	1 Yr 11 M	2	1.5	1	4.5	2	2.76	2	3	1	4.5	2.75	3.5
14	2 Yr	1	--	1.5	--	0.25	--	0.25	0.25	--	0.5	0.75	0.75
15	2 Yr	0.25	2.75	3.5	2.25	--	5.25	2.75	2.25	1.25	1.25	1.25	1.75
16	2 Yr 4 M	4.25	1.75	3.5	8.25	11	17.5	11.25	5.25	7.5	11	6.5	5.75
17	2 Yr 5 M	1.5	--	--	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	0.25	1	--	1	1	1	0.75	--	1.75	1.5	0.5	0.25
19	3 Yr	--	--	2	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	3.5	0.75	3.75	2	2	6.25	5.5	2.5	4.5	4.5	4.5	3.25
21	4 Yr 6 M	3	1.75	4	1	5	8.5	6.5	6.5	5.25	3.75	5.25	4.25
22	4 Yr 6 M	--	--	--	--	--	--	--	--	—	0.25	0.25	1.5
23	4 Yr 11 M	--	--	2	--	--	0.75	1.5	0.5	--	1.75	2	1.25
24	5 Yr	1.75	2.25	1.5	--	--	8.25	9.25	68.25	15.75	7.75	4	3.25
25	5 Yr	1	2	2.25	2.75	2.5	2	2	2.5	3.25	0.25	1.5	1.5
26	5 Yr 1 M	26.75	15.25	32	24.5	30	--	--	--	--	--	--	--
27	5 Yr 2 M	2.75	1.5	4.5	2.75	2.5	4.25	4	2.75	2.5	1.75	1.5	2.25

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
28	5 Yr 3 M	0.5	0.75	1.25	1.75	1.5	0.5	3.5	0.5	0.75	1.25	--	0.25
29	5 Yr 4 M	--	--	--	--	--	1.75	3	1.75	1.5	1.25	2.5	2.25
30	5 Yr 8 M	--	0.25	0.75	0.25	1.25	0.5	1	0.25	1.5	0.75	2.5	0.75
31	5 Yr 9 M	2.5	3.75	7.5	12.75	3	5.75	6	1.25	6.25	5	2.75	4
32	5 Yr 11 M	1.75	1.5	2.5	2	--	1	2	0.75	0.75	1.25	0.75	0.5
33	6 Yr	1	1.75	3.5	0.75	--	1.25	0.5	2	2	0.75	0.75	1.5
34	6 Yr 2 M	0.5	1.25	0.5	0.75	--	--	--	0.75	0.25	0.5	0.5	0.25
35	6 Yr 2 M	2	2.75	--	1.25	1.25	1.75	1.75	5.25	2.25	--	--	--
36	6 Yr 9 M	5	1.75	6	5	4.5	7.75	3.75	4.75	6.5	--	--	--
37	6 Yr 10 M	2.75	2.5	--	2	0.75	0.75	1.75	0.75	1	1.25	2.5	8.25
38	6 Yr 11 M	--	--	--	--	--	1.75	2.25	1.75	3.25	4.25	2.5	5
39	7 Yr	--	0.75	1.75	1	0.75	1	2.25	0.25	--	0.75	0.75	0.75
40	7 Yr 1 M	--	--	--	--	--	5.5	3.5	6	5.75	4.5	4.75	6
41	7 Yr 3 M	0.25	1.75	0.75	--	0.75	0.75	1.5	0.25	0.5	0.75	0.5	1
42	7 Yr 9 M	1	--	3.5	4.75	2.5	12.25	6.5	3	4.25	7.5	3.75	3
43	8 Yr 3 M	1.0	4	3.5	6.5	4.25	2	8.25	18.5	3.5	2.5	2.75	4.5
44	10 Yr	0.75	1.75	--	1.75	2.5	4.75	2.5	3.75	3.75	5.25	3	3.25
Mean		2.47	2.22	3.59	3.72	3.39	3.34	3.05	4.12	2.51	2.53	2.07	2.4
S/D		4.73	2.68	5.65	5.07	5.85	3.69	2.56	10.72	2.88	2.56	1.70	2.2
n		32	30	30	29	26	40	40	41	41	39	39	39

Overall mean for all the bulls sampled in 1977: 2.89%
SD: 0.75%
n: 426

Distal Cytoplasmic Droplets

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	1	1.25	0.25	1	0.5	2	0.5
2	8 M	--	--	--	--	--	1.25	0.5	--	--	1	1.5	0.75
3	9 M	--	--	--	--	--	1	3.5	0.5	0.5	1.5	0.8	0.5
4	10 M	--	--	--	--	--	2.75	1.25	1.25	2.5	1.5	1.25	1.75
5	10 M	--	--	--	--	--	0.5	2	--	1.75	2	0.75	2
6	1 Yr	--	--	--	--	--	0.25	1.5	1.75	0.5	1.5	1	5
7	1 Yr 1 M	2.75	--	0.5	4.25	3	--	1	0.25	2.25	0.5	0.5	4
8	1 Yr 1 M	--	--	--	0.25	2.75	0.5	0.5	--	1.75	0.25	0.75	--
9	1 Yr 3 M	0.75	2.25	0.5	--	1.5	0.25	2	--	1	1.75	0.5	0.75
10	1 Yr 9 M	--	--	0.5	1	1	2	0.5	0.75	1	2.5	0.25	1.5
11	1 Yr 9 M	1	1	1	3.5	2.5	1.25	1	--	6.75	0.5	--	8.25
12	1 Yr 10 M	0.75	1	0.5	3.5	0.75	4	1.25	0.5	--	--	1	0.75
13	1 Yr 11 M	0.25	--	0.75	2	1.5	0.75	1	--	1	0.25	0.75	0.5
14	2 Yr	0.5	--	--	0.25	1.25	0.5	1.5	0.5	0.25	0.25	0.25	1.5
15	2 Yr	0.5	1	1	2.5	--	5	4.25	0.75	2.25	5.5	4	5
16	2 Yr 4 M	--	--	0.25	0.75	3.5	2.75	1.5	1.5	3.25	--	3.5	3.5
17	2 Yr 5 M	0.25	--	--	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1.75	--	--	1.25	1.75	3.25	0.5	--	1.25	4	--	0.25
19	3 Yr	--	--	3	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	0.5	1.25	0.5	1.75	1.5	12.5	8	1.75	1.75	5.25	5.25	5.25
21	4 Yr 6 M	0.5	0.75	1.5	1.25	5.75	4.25	4.75	3	6.5	3.25	6.5	5.5
22	4 Yr 6 M	--	--	--	--	--	0.75	--	0.25	0.25	0.25	0.75	0.5
23	4 Yr 11 M	--	--	0.25	--	--	0.25	0.75	0.5	2	3	2	1.75
24	5 Yr	0.25	0.5	0.25	--	--	1.5	2	--	6	2.75	1.75	1.5
25	5 Yr	0.75	0.5	41	0.5	0.75	1.5	0.75	0.25	0.75	1.25	1	--
26	5 Yr 1 M	--	1.5	--	8.5	2.75	--	--	--	--	--	--	--
27	5 Yr 2 M	0.75	0.25	0.5	2.25	1.75	0.75	1	1.75	1.25	5.5	2.25	1.25

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
28	5 Yr 3 M	0.75	0.25	--	0.75	0.75	2	2	0.75	0.75	1.5	1.25	0.5
29	5 Yr 4 M	--	--	--	--	--	2	1.25	1	0.75	3	2.5	3
30	5 Yr 8 M	0.25	--	--	0.75	0.75	0.25	0.25	0.25	--	0.25	16.75	0.75
31	5 Yr 9 M	15.25	0.5	0.5	3.25	23.5	5	3.5	--	2.25	6	5.5	6
32	5 Yr 11 M	1	--	0.25	1.25	--	1	1.25	0.75	0.75	25.75	2.25	0.25
33	6 Yr	1.75	--	0.25	0.25	--	3	0.75	0.25	1.25	1.5	1.75	2.75
34	6 Yr 2 M	1.25	0.25	--	0.25	--	--	--	0.75	1.25	0.75	0.75	0.75
35	6 Yr 2 M	--	1.25	--	3	2	2.5	1.75	--	0.25	--	--	--
36	6 Yr 9 M	1	0.5	1.25	1.75	3.5	16.25	0.75	0.75	2.75	--	--	--
37	6 Yr 10 M	0.25	--	--	1.5	0.75	1.5	0.75	1	0.75	1.25	2	2.25
38	6 Yr 11 M	--	--	--	--	--	2.75	1.75	2.75	2.75	3.25	1.5	3
39	7 Yr	--	0.5	--	0.25	1	1	1.75	1.25	0.25	1.25	0.5	0.75
40	7 Yr 1 M	--	--	--	--	--	0.25	3.75	0.25	2.25	2.25	3.25	3
41	7 Yr 3 M	--	--	0.75	--	--	--	--	0.75	0.5	0.75	0.5	0.8
42	7 Yr 9 M	--	--	0.75	2.75	5.25	8.25	7	0.75	2.25	7	4.25	2
43	8 Yr 3 M	1.25	0.25	1	0.75	--	2	5	13.5	2.75	0.25	3	10.25
44	10 Yr	1	0.5	--	0.5	2.25	4.25	8	1.5	3.25	3	6	1.25
Mean		1.09	0.47	1.89	1.74	2.76	2.51	2.04	1.02	1.71	2.63	2.31	2.30
S/D		2.66	0.56	7.41	1.76	4.46	3.28	2.04	2.13	1.63	4.22	2.92	2.34
n		32	30	30	29	26	40	40	41	41	39	39	39

Overall mean for all the bulls sampled in 1977: 1.87%
SD: 0.71
n: 426

Middle Piece Abnormalities (viz: Swollen, Double, Rough, Coiled)

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	--	0.75	0.25	0.5	--	0.25	0.75
2	8 M	--	--	--	--	--	1.25	--	--	0.25	--	0.25	0.5
3	9 M	--	--	--	--	--	0.5	--	0.25	--	0.25	0.2	0.5
4	10 M	--	--	--	--	--	--	0.25	--	--	1	1.25	--
5	10 M	--	--	--	--	--	--	1.75	--	0.25	1	--	--
6	1 Yr	--	--	--	--	--	--	--	0.25	0.25	0.5	0.25	0.25
7	1 Yr 1 M	--	1	0.5	0.5	--	0.25	--	--	0.25	0.25	--	--
8	1 Yr 1 M	2.75	--	1	3.25	1	0.75	0.75	0.25	1.75	1.25	0.5	0.25
9	1 Yr 3 M	--	0.5	0.25	0.5	0.25	0.75	0.25	--	--	1.5	0.5	0.25
10	1 Yr 9 M	1.25	1.75	1.25	--	--	--	--	--	0.5	0.5	0.75	0.25
11	1 Yr 9 M	0.25	0.25	0.5	--	0.5	0.75	0.5	0.5	--	0.5	0.25	--
12	1 Yr 10 M	0.5	1.25	1.75	1	0.75	0.75	1	--	0.5	1.5	1	0.75
13	1 Yr 11 M	0.5	--	0.75	0.25	0.25	--	0.75	0.5	--	--	0.25	--
14	2 Yr	0.5	--	0.25	0.25	0.25	0.75	--	--	--	--	0.25	--
15	2 Yr	2	0.5	1.25	0.75	--	1	1.75	0.5	1	0.25	0.25	--
16	2 Yr 5 M	--	--	--	0.5	--	0.25	--	--	0.25	--	0.25	--
17	2 Yr 5 M	0.25	--	--	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1	--	1.25	0.5	1.25	1.25	0.5	--	0.25	0.5	0.75	0.25
19	3 Yr	--	--	--	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	0.5	1	0.5	--	--	0.5	1.25	0.25	--	1.75	--	--
21	4 Yr 6 M	--	0.75	1	0.25	0.25	0.5	--	0.25	--	0.75	0.25	0.25
22	4 Yr 6 M	--	--	--	--	--	0.5	0.5	--	--	0.25	--	--
23	4 Yr 11 M	--	--	0.25	--	--	0.5	--	--	0.25	0.75	--	0.5
24	5 Yr	0.5	0.75	--	--	--	--	1	0.5	0.25	1.5	0.75	0.25
25	5 Yr	--	--	--	--	0.25	1	--	--	--	0.5	--	1
26	5 Yr 1 M	--	0.25	1	0.75	--	--	--	--	--	--	--	--
27	5 Yr 2 M	--	0.5	0.5	--	--	0.5	--	--	--	--	0.25	--

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
28	5 Yr 3 M	0.5	0.25	--	1.25	0.5	0.5	0.5	0.25	--	0.75	0.25	--
29	5 Yr 4 M	--	--	--	--	--	0.25	0.25	--	0.5	--	0.25	--
30	5 Yr 8 M	1.75	0.25	1	0.25	--	0.5	0.5	--	0.25	0.25	0.25	0.5
31	5 Yr 9 M	--	--	0.75	0.5	4.5	0.5	1.25	0.25	--	1	0.25	0.5
32	5 Yr 11 M	0.75	--	1	0.75	--	--	--	0.25	--	0.25	--	--
33	6 Yr	2	0.5	--	--	--	0.5	0.75	0.25	--	0.5	--	--
34	6 Yr 2 M	0.25	--	0.75	0.25	--	--	--	--	0.25	--	0.25	0.5
35	6 Yr 2	--	0.5	--	--	--	1	0.75	--	--	--	--	--
36	6 Yr 9 M	--	1.25	0.5	0.25	0.25	0.25	0.25	--	--	--	--	--
37	6 Yr 10 M	0.25	--	--	1.25	0.25	0.75	0.5	--	--	0.5	--	0.25
38	6 Yr 11 M	--	--	--	--	--	0.5	0.25	--	0.5	0.25	--	--
39	7 Yr	1.75	0.25	0.25	0.25	0.75	0.25	0.25	--	--	0.5	--	0.5
40	7 Yr 1 M	--	--	--	--	--	0.5	0.25	--	--	0.5	--	0.5
41	7 Yr 3 M	1.5	0.75	1	--	0.25	--	1	--	--	0.25	0.5	1.4
42	7 Yr 9 M	--	--	0.5	0.25	0.25	1	0.5	--	--	1	0.75	0.5
43	8 Yr 3 M	1.5	1	--	0.25	0.25	0.5	1	--	0.5	0.5	--	0.25
44	10 Yr	--	8	--	--	0.25	0.25	0.75	--	--	0.25	--	0.25
Mean		0.63	0.71	0.59	0.47	0.46	0.48	0.49	0.11	0.20	0.54	0.27	0.28
S/D		0.77	1.45	0.48	0.65	0.88	0.36	0.48	0.16	0.34	0.48	0.31	0.32
n		32	30	30	29	26	40	40	41	41	39	39	39

Overall mean for all the bulls sampled in 1977: 0.44%
SD: 0.18
n: 426

Abaxial Attachment of the Middle-Piece

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	--	--	--	--	--	--	--
2	8 M	--	--	--	--	--	--	--	--	--	--	--	--
3	9 M	--	--	--	--	--	--	0.5	--	--	--	--	--
4	10 M	--	--	--	--	--	--	--	--	--	--	--	--
5	10 M	--	--	--	--	--	--	--	--	--	--	--	--
6	1 Yr	--	--	--	--	--	--	--	--	--	--	--	0.25
7	1 Yr 1 M	--	--	--	--	--	--	--	--	--	--	--	--
8	1 Yr 1 M	--	17.5	--	--	--	--	--	0.25	--	--	--	--
9	1 Yr 3 M	--	--	--	--	--	--	--	--	--	--	--	--
10	1 Yr 9 M	--	--	--	--	--	--	--	--	--	--	--	--
11	1 Yr 9 M	--	--	--	--	--	--	--	--	--	--	--	--
12	1 Yr 10 M	--	--	--	2	--	--	--	--	--	--	--	--
13	1 Yr 11 M	--	--	--	--	--	--	--	--	--	--	--	--
14	2 Yr	--	--	--	--	--	--	--	--	--	--	--	--
15	2 Yr	--	--	--	--	--	--	--	--	--	--	--	--
16	2 Yr 4 M	--	--	--	--	0.25	--	--	--	--	--	--	--
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	20.25	--	17.75	0.25	--	--	--	--	--	--	--	--
19	3 Yr	--	--	--	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	--	--	0.25	--	--	--	--	--	--	--	--	0.25
21	4 Yr 6 M	--	--	0.5	--	--	--	--	--	0.75	--	--	--
22	4 Yr 6 M	--	--	--	--	--	--	--	--	--	--	--	--
23	4 Yr 11 M	--	--	0.25	--	--	--	--	--	--	--	--	--
24	5 Yr	--	0.75	--	--	--	--	--	--	--	--	--	--
25	5 Yr	--	--	--	--	--	--	--	--	--	--	--	--
26	5 Yr 1 M	--	--	--	--	--	--	--	--	--	--	--	--
27	5 Yr 2 M	--	--	--	--	--	--	--	--	--	--	--	--

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
28	5 Yr 3 M	--	--	--	--	--	--	--	--	--	--	--	0.25
29	5 Yr 4 M	--	--	--	--	--	--	--	--	--	--	--	--
30	5 Yr 8 M	--	--	--	--	--	--	--	--	--	--	--	--
31	5 Yr 9 M	--	--	--	0.5	0.25	--	1.25	--	--	--	--	--
32	5 Yr 11 M	--	--	--	--	--	--	--	--	--	--	--	--
33	6 Yr	1	--	--	--	--	--	--	--	--	--	0.25	--
34	6 Yr 2 M	--	--	--	--	--	--	--	0.25	--	--	--	--
35	6 Yr 2 M	--	--	--	--	--	--	--	--	--	--	--	--
36	6 Yr 9 M	--	--	--	--	--	--	--	--	--	--	--	--
37	6 Yr 10 M	--	--	--	--	--	--	--	--	--	--	--	--
38	6 Yr 11 M	--	--	--	--	--	--	--	--	--	--	--	--
39	7 Yr	--	0.75	0.5	--	--	--	--	0.25	--	--	--	--
40	7 Yr 1 M	--	--	--	--	--	--	--	--	--	--	--	--
41	7 Yr 3 M	--	--	--	--	--	--	--	--	--	--	--	--
42	7 Yr 9 M	0.75	--	--	--	--	--	--	--	--	--	--	0.25
43	8 Yr 3 M	--	--	--	--	--	--	--	--	--	--	--	--
44	10 Yr	--	--	--	--	--	--	--	--	--	--	--	--
Mean		0.69	0.63	0.64	0.09	0.02	0	0.04	0.02	0.02	0	0.01	0.03
S/D		3.58	3.19	3.23	0.38	0.07	0	0.21	0.07	0.12	0	0.04	0.08
n		32	30	30	29	26	40	40	41	41	39	39	39

Overall mean for all bulls sampled in 1977: 0.18%
SD: 0.29
n: 426

Tail Abnormalities

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	2	1	0.25	0.75	1.25	1	2
2	8 M	--	--	--	--	--	0.5	0.5	3	0.25	1.5	0.25	0.75
3	9 M	--	--	--	--	--	2	2.75	1.75	0.5	1.75	2.0	1.25
4	10 M	--	--	--	--	--	1.5	1	2.75	2.5	0.75	3	1.5
5	10 M	--	--	--	--	--	0.5	0.75	2.5	0.75	0.5	0.25	0.25
6	1 Yr	--	--	--	--	--	0.75	2.5	1.75	2	1.5	2.25	0.75
7	1 Yr 1 M	2.75	1.5	1.25	1.5	0.25	--	--	0.75	0.75	1	1.25	0.75
8	1 Yr 1 M	5.5	--	8.75	1.5	2.75	2.25	2.25	3.25	2	1.25	2.5	2.5
9	1 Yr 3 M	1.75	5.25	1.5	0.25	1	1.25	0.5	1.5	0.5	2.25	1	2
10	1 Yr 9 M	7	5	4	3	2.75	0.5	2.25	3.75	0.25	0.75	1.25	1.5
11	1 Yr 9 M	4.5	4.5	2.5	1.5	1	1	2	1.5	1.75	0.75	1.5	1
12	1 Yr 10 M	5.25	8.25	3.75	5	2.75	4.25	3.75	3.5	2.75	3.75	3.5	1.25
13	1 Yr 11 M	1.75	2.5	1.75	0.25	--	--	0.5	1	1	0.75	1.25	0.5
14	2 Yr	5	2.5	4.75	1.25	0.75	0.25	0.25	1.25	1.25	6.25	0.75	1
15	2 Yr	2.5	3.5	5.5	2.75	--	1.75	11.75	4.25	2	5.5	2.25	1.25
16	2 Yr 5 M	4.25	11.25	4	1	3.5	2.25	6.5	1.25	0.75	1.5	2	1.25
17	2 Yr 5 M	2.5	--	--	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1	4.5	1	1.5	0.75	1.25	4	1	1.25	1.25	1	2.25
19	3 Yr	--	--	14	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	7.75	9.75	5	2.75	4.5	3.5	19.25	3.25	2.25	7.5	6.5	3.25
21	4 Yr 6 M	4.75	16	6	4.25	26.25	29.5	45.5	45.25	38.25	19.5	30	17
22	4 Yr 6 M	--	--	--	--	--	0.5	1.5	1.25	1	1	1.25	1
23	4 Yr 11 M	--	--	1.75	--	--	0.25	0.75	0.75	1.5	0.5	1.5	1
24	5 Yr	1.75	3.5	2	--	--	3	6.5	4.25	6.75	6	2.25	1.75
25	5 Yr	10	3.75	2.25	1.5	--	0.5	1.25	1.5	1	0.75	0.5	2.75
26	5 Yr 1 M	7	4.25	2.25	2	4.5	--	--	--	--	--	--	--
27	5 Yr 2 M	18.5	2.5	1.75	1.25	--	0.5	1	0.25	--	1	0.75	0.75

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
28	5 Yr 3 M	3.75	4.25	4.25	5.25	1.75	1.75	6.5	14.75	1.5	1.75	1.5	2.75
29	5 Yr 4 M	--	--	--	--	--	2	1.25	1.25	0.25	0.5	2.5	1.25
30	5 Yr 8 M	0.75	9	6.75	1.25	3.5	0.75	1.25	0.75	0.25	1.5	1.25	1
31	5 Yr 9 M	5	9.5	5.5	1	0.25	2	2	12.75	0.5	2.25	2.75	1.75
32	5 Yr 11 M	2.75	5.75	3	1.25	--	1.75	1.25	1	0.75	6	1.75	7
33	6 Yr	7	7	4	2.5	--	2.75	0.5	2.5	2	2.5	5	4.25
34	6 Yr 2 M	2.5	2.1	0.75	0.75	--	--	--	0.5	1.75	0.5	1.5	0.75
35	6 Yr 2 M	4.5	2.25	--	1	2	1.25	2.5	4	1	--	--	--
36	6 Yr 9 M	16	15.25	13.25	22.5	15	21.25	15.5	15	17.75	--	--	--
37	6 Yr 10 M	2.5	4.5	--	0.25	1	1.5	0.75	1.25	0.75	0.5	1	1
38	6 Yr 11 M	--	--	--	--	--	0.75	0.75	1	1	0.25	1	0.75
39	7 Yr	0.75	2.5	1.75	0.25	0.5	0.5	0.75	0.5	0.75	0.25	2.25	1.75
40	7 Yr 1 M	--	--	--	--	--	6	2.5	0.25	0.5	1.75	2	4.75
41	7 Yr 3 M	2.5	3.5	0.5	--	0.5	0.75	1	0.75	1	4	2.25	1.8
42	7 Yr 9 M	5.25	--	4.25	6	10.75	14.5	21.25	15.5	7.5	6	7	3.25
43	8 Yr 3 M	2.25	3.5	11.25	1.5	0.25	0.75	8.5	3.5	3.5	1.25	9	1.25
44	10 Yr	4.5	8	--	10.5	4.75	3.5	2.25	1.25	1.75	1.5	2.5	1.75
Mean		4.80	5.52	4.30	2.94	3.50	3.04	4.66	4.10	2.79	2.54	2.90	2.16
S/D		3.95	3.85	3.50	4.35	5.77	5.79	8.31	7.70	6.40	3.41	4.81	2.77
n		32	30	30	29	26	40	40	41	41	39	39	39

Overall mean for all the bulls sampled in 1977: 3.60%
SD: 1.05

Tail-less Heads

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1	7 M	--	--	--	--	--	0.25	0.25	0.25	0.25	--	0.5	0.5
2	8 M	--	--	--	--	--	1	0.25	--	0.5	0.25	0.5	1
3	9 M	--	--	--	--	--	--	0.25	0.5	0.5	0.5	0.6	--
4	10 M	--	--	--	--	--	--	--	--	0.25	0.25	--	0.25
5	10 M	--	--	--	--	--	0.5	--	0.25	--	--	0.5	0.25
6	1 Yr	--	--	--	--	--	1.5	0.25	0.25	1	0.25	0.75	0.5
7	1 Yr 1 M	3.25	0.5	1	0.5	0.25	0.25	0.25	0.5	--	--	0.5	0.5
8	1 Yr 1 M	1.5	1.5	1.25	1.25	1	--	--	0.25	--	0.25	0.25	--
9	1 Yr 3 M	1.5	0.5	0.5	0.75	--	1	0.25	0.5	0.5	--	--	0.75
10	1 Yr 9 M	1.75	3.25	0.5	--	0.25	0.25	0.75	--	0.5	0.5	0.5	0.5
11	1 Yr 9 M	6	6	2.5	0.5	0.5	--	--	0.75	0.25	--	1.5	0.75
12	1 Yr 10 M	6	7.5	4	3.25	2.25	2.75	1.75	0.25	0.5	2.75	3.75	2.5
13	1 Yr 11 M	2.25	3	0.5	--	--	1	0.5	0.25	--	--	0.25	0.25
14	2 Yr	12.25	13.75	1.25	0.5	0.75	0.75	1.5	1	0.75	0.25	1.25	0.25
15	2 Yr	7.75	3.75	2.5	--	--	0.75	2.25	0.25	1.25	1.25	1.25	--
16	2 Yr 4 M	3	7	3	1.25	1.5	0.75	2.75	0.5	1	2	1.25	--
17	2 Yr 5 M	1.75	--	--	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	0.5	2.75	1	--	0.5	1	0.25	--	0.25	0.75	0.75	--
19	3 Yr	--	--	3	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	1.75	0.5	0.75	--	0.25	1.5	0.5	0.5	0.5	--	0.5	0.5
21	4 Yr 6 M	3	10.75	2.5	0.25	5.25	2.75	2.25	4	7	2.5	1.75	1.75
22	4 Yr 6 M	--	--	--	--	--	0.5	0.5	0.25	1	1.5	0.75	0.5
23	4 Yr 11 M	--	--	0.75	--	--	--	0.5	0.25	--	--	0.5	--
24	5 Yr	4.25	2.5	1.25	--	--	3.25	--	0.5	0.25	--	0.25	--
25	5 Yr	0.5	1.5	0.5	--	0.25	0.25	--	--	0.5	0.25	1.25	--
26	5 Yr 1 M	2	5.75	5	--	8.5	--	--	--	--	--	--	--
27	5 Yr 2 M	1.5	6.25	1.75	--	--	0.25	1	--	0.25	2	0.25	0.25

Bull No.	Age at January 1977	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
28	5 Yr 3 M	2.25	5	0.5	--	--	0.25	0.5	--	0.25	0.75	0.5	--
29	5 Yr 4 M	--	--	--	--	--	0.5	--	--	0.75	--	--	0.25
30	5 Yr 8 M	0.75	1	1.25	--	0.25	0.75	0.75	--	0.25	0.25	0.5	0.5
31	5 Yr 9 M	0.75	2.75	0.5	0.75	1.75	1	0.25	0.75	0.25	0.25	0.25	--
32	5 Yr 11 M	0.75	0.75	1.25	--	--	--	0.75	0.75	0.75	1.25	0.25	--
33	6 Yr	6.25	7	3	--	--	1.25	-	1	1.25	0.25	0.25	0.5
34	6 Yr 2 M	2	1.75	0.25	--	--	--	--	1.25	1	1	0.5	1
35	6 Yr 2 M	1	1.25	--	0.25	1	0.25	0.5	0.25	0.25	--	--	--
36	6 Yr 9 M	1.5	4.25	1.75	--	0.25	0.75	--	0.25	5	--	--	--
37	6 Yr 10 M	1.5	0.25	--	1	0.25	0.25	0.25	0.25	--	1.5	--	--
38	6 Yr 11 M	--	--	--	--	--	--	0.25	0.25	--	0.25	1	--
39	7 Yr	12.75	3	1.75	0.75	--	--	0.25	--	0.25	0.25	0.5	0.5
40	7 Yr 1 M	--	--	--	--	--	0.5	--	--	--	0.5	0.25	0.75
41	7 Yr 3 M	1.25	2	0.5	--	--	0.5	--	0.5	--	0.25	1	0.6
42	7 Yr 9 M	1.75	--	2.5	0.25	0.25	--	1	0.25	0.5	0.75	0.5	--
43	8 Yr 3 M	4.25	3.75	2.5	0.75	--	3	2	7	6.25	1.25	--	--
44	10 Yr	1	5	--	5	--	0.75	2	0.5	1.75	--	--	0.25
Mean		3.07	3.82	1.64	0.59	0.96	0.75	0.61	0.59	0.87	0.61	0.64	0.39
S/D		3.08	3.17	1.18	1.08	1.90	0.85	0.75	1.21	1.56	0.74	0.68	0.51
n		32	30	30	29	26	40	40	41	41	39	39	39

Overall mean for all the bulls sampled in 1977: 0.93%
SD: 0.75
n: 426

APPENDIX E

1977 MONTHLY RECORD OF PERCENTAGE ABNORMAL SPERMATOZOA IN DAIRY BULLS USED FOR ARTIFICIAL INSEMINATION AND PROCEDURES FOR THE PREPARATION OF WILLIAMS STAIN AND BUFFERED FORMAL SALINE

Figure 1. Total Abnormalities Per Bull for January 1977

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns.,(Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	--	--	--	--	--	--	--	--	--
2	8 M	--	--	--	--	--	--	--	--	--
3	9 M	--	--	--	--	--	--	--	--	--
4	10 M	--	--	--	--	--	--	--	--	--
5	10 M	--	--	--	--	--	--	--	--	--
6	1 Yr	--	--	--	--	--	--	--	--	--
7	1 Yr 1 M	--	2.75	3.25	1.0	2.75	--	--	1.6	9.75
8	1 Yr 1 M	1.75	--	1.5	0.25	5.5	2.75	--	3.6	15.35
9	1 Yr 3 M	0.25	0.75	1.5	--	1.75	--	--	1.2	5.45
10	1 Yr 9 M	2.25	--	1.75	0.75	7	1.25	--	0.6	13.6
11	1 Yr 9 M	0.25	1	6	--	4.5	0.25	--	1	13.0
12	1 Yr 10 M	7.5	0.75	6	--	5.25	0.5	--	4.8	24.8
13	1 Yr 11 M	2	0.25	2.25	0.5	1.75	0.5	--	2.4	9.65
14	2 Yr	1	0.5	12.25	--	5	0.5	--	0.8	20.05
15	2 Yr	0.25	0.5	7.75	0.5	2.5	2	--	2.2	15.70
16	2 Yr 4 M	4.25	--	3	0.5	4.25	--	--	0.8	12.80
17	2 Yr 5 M	1.5	0.25	1.75	0.75	2.5	0.25	--	1	8
18	2 Yr 11 M	0.25	1.75	0.5	0.75	1	1	20.25	1	26.5
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	3.5	0.5	1.75	0.25	7.75	0.5	--	3.2	17.45
21	4 Yr 6 M	3	0.5	3	0.25	4.75	--	--	1.6	13.10
22	4 Yr 6 M	--	--	--	--	--	--	--	--	--
23	4 Yr 11 M	--	--	--	--	--	--	--	--	--
24	5 Yr	1.75	0.25	4.25	1	1.75	0.5	--	4	13.50
25	5 Yr	1	0.75	0.5	1	10	--	--	2.2	15.45
26	5 Yr 1 M	26.75	--	2	--	7	--	--	1.2	36.95
27	5 Yr 2 M	2.75	0.75	1.5	--	18.5	--	--	2	25.50

Figure 1. Total Abnormalities Per Bull for January 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns.,(Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	0.5	0.75	2.25	0.5	3.75	0.5	--	0.8	9.05
29	5 Yr 4 M	--	--	--	--	--	--	--	--	--
30	5 Yr 8 M	--	0.25	0.75	0.5	0.75	1.75	--	1	5.0
31	5 Yr 9 M	2.5	15.25	0.75	0.5	5	--	--	1.8	25.80
32	5 Yr 11 M	1.75	1	0.75	0.75	2.75	0.75	--	1.4	9.15
33	6 Yr	1	1.75	6.25	--	7	2	1	0.8	19.8
34	6 Yr 2 M	0.5	1.25	2	--	2.5	0.25	--	1.8	8.3
35	6 Yr 2 M	2	--	1	--	4.5	--	--	1.6	9.1
36	6 Yr 9 M	5	1	1.5	--	16	--	--	4.6	28.1
37	6 Yr 10 M	2.75	0.25	1.5	--	2.5	0.25	--	1	8.25
38	6 Ur 11 M	--	--	--	--	--	--	--	--	--
39	7 Yr	--	--	12.75	0.5	0.75	1.75	--	0.6	16.35
40	7 Yr 1 M	--	--	--	--	--	--	--	--	--
41	7 Yr 3 M	0.25	--	1.25	--	2.5	1.5	--	1	6.5
42	7 Yr 9 M	1	--	1.75	3.5	5.25	--	0.75	4.2	16.45
43	8 Yr 3 M	1.0	1.25	4.25	2.25	2.25	1.5	--	1.8	14.3
44	10 Yr	0.75	1	1	1	4.5	--	--	2.6	10.85

Figure 2. Total Abnormalities Per Bull for February 1977

Bull No.	Age at January 1977	Pro. Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	--	--	--	--	--	--	--	--	--
2	8 M	--	--	--	--	--	--	--	--	--
3	9 M	--	--	--	--	--	--	--	--	--
4	10 M	--	--	--	--	--	--	--	--	--
5	10 M	--	--	--	--	--	--	--	--	--
6	1 Yr	--	--	--	--	--	--	--	--	--
7	1 Yr 1 M	1.75	--	0.5	--	1.5	1	--	0.6	5.35
8	1 Yr 1 M	2	--	1.5	--	--	--	17.5	2.2	23.2
9	1 Yr 3 M	1.5	2.25	0.5	0.5	5.25	0.5	--	0.8	11.3
10	1 Yr 9 M	1.25	--	3.25	--	5	1.75	--	1.4	12.65
11	1 Yr 9 M	0.25	1	6	--	4.5	0.25	--	0.6	12.60
12	1 Yr 10 M	4.75	1	7.5	--	8.25	1.25	--	2	24.75
13	1 Yr 11 M	1.5	--	3	1	2.5	--	--	1.8	9.80
14	2 Yr	--	--	13.75	--	2.5	--	--	1	17.25
15	2 Yr	2.75	1	3.75	--	3.5	0.5	--	1.8	13.3
16	2 Yr 4 M	1.75	--	7	0.25	11.25	--	--	2	22.25
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1	--	2.75	0.25	4.5	--	--	1.2	9.70
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	0.75	1.25	0.5	0.5	9.75	1	--	2.6	16.35
21	4 Yr 6 M	1.75	0.75	10.75	--	16	0.75	--	2.2	32.20
22	4 Yr 6 M	--	--	--	--	--	--	--	--	--
23	4 Yr 11 M	--	--	--	--	--	--	--	--	--
24	5 Yr	2.25	0.5	2.5	1	3.5	0.75	0.75	2.6	13.85
25	5 Yr	2	0.5	1.5	0.5	3.75	--	--	2.6	10.85
26	5 Yr 1 M	15.25	1.5	5.75	--	4.25	0.25	--	2.4	29.40
27	5 Yr 2 M	1.5	0.25	6.25	--	2.5	0.5	--	2	13.0

Figure 2. Total Abnormalities Per Bull for February 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns.,(Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	0.75	0.25	5	0.75	4.25	0.25	--	1.4	12.65
29	5 Yr 4 M	--	--	--	--	--	--	--	--	--
30	5 Yr 8 M	0.25	--	1	--	9	0.25	--	0.8	11.30
31	5 Yr 9 M	3.75	0.5	2.75	0.5	9.5	--	--	1	18.0
32	5 Yr 11 M	1.5	--	0.75	--	5.75	--	--	2.2	10.20
33	6 Yr	1.75	--	7	--	7	0.5	--	0.6	16.85
34	6 Yr 2 M	1.25	0.25	1.75	0.75	2.1	--	--	1	7.1
35	6 Yr 2 M	2.75	1.25	1.25	--	2.25	0.5	--	5.8	13.80
36	6 Yr 9 M	1.75	0.5	4.25	--	15.25	1.25	--	1.2	24.20
37	6 Yr 10 M	2.5	--	0.25	0.75	4.5	--	--	1.2	9.20
38	6 Yr 11 M	--	--	--	--	--	--	--	--	--
39	7 Yr	0.75	0.5	3	--	2.5	0.25	0.75	1	8.75
40	7 Yr 1 M	--	--	--	--	--	--	--	--	--
41	7 Yr 3 M	1.75	--	2	--	3.5	0.75	--	1.6	9.60
42	7 Yr 9 M	--	--	--	--	--	--	--	--	--
43	8 Yr 3 M	4	0.25	3.75	--	3.5	1	--	2.4	15.15
44	10 Yr	1.75	0.5	5	1.75	8	8	--	3.6	28.6

Figure 3. Total Abnormalities Per Bull for March 1977

Bull No.	Age at January 1977	Pro. Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	--	--	--	--	--	--	--	--	--
2	8 M	--	--	--	--	--	--	--	--	--
3	9 M	--	--	--	--	--	--	--	--	--
4	10 M	--	--	--	--	--	--	--	--	--
5	10 M	--	--	--	--	--	--	--	--	--
6	1 Yr	--	--	--	--	--	--	--	--	--
7	1 Yr 1 M	2.75	0.5	1	--	1.25	0.5	--	1.2	7.20
8	1 Yr 1 M	3.5	--	1.25	--	8.75	1	--	2	16.50
9	1 Yr 3 M	1.25	0.5	0.5	--	1.5	0.25	--	1	5
10	1 Yr 9 M	1.75	0.5	0.5	--	4	1.25	--	0.8	8.8
11	1 Yr 9 M	--	1	2.5	1.75	2.5	0.5	--	1.2	9.45
12	1 Yr 10 M	5.5	0.5	4	--	3.75	1.75	--	2.2	17.7
13	1 Yr 11 M	1	0.75	0.5	0.75	1.75	0.75	--	1.6	7.1
14	2 Yr	1.5	--	1.25	--	4.75	0.25	--	1	8.75
15	2 Yr	3.5	1	2.5	1	5.5	1.25	--	2	16.75
16	2 Yr 4 M	3.5	0.25	3	--	4	--	--	0.6	11.35
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	--	--	1	0.25	1	1.25	17.75	1.8	23.05
19	3 Yr	2	3	3	--	14	--	--	2	24.00
20	3 Yr 11 M	3.75	0.5	0.75	1.25	5	0.5	0.25	2	14.00
21	4 Yr 6 M	4	1.5	2.5	0.5	6	1	0.5	1.6	17.6
22	4 Yr 6 M	--	--	--	--	--	--	--	--	--
23	4 Yr 11 M	2	0.25	0.75	0.5	1.75	0.25	0.25	1	6.75
24	5 Yr	1.5	0.25	1.25	0.25	2	--	--	1.4	6.65
25	5 Yr	2.25	41	0.5	--	2.25	--	--	0.6	46.6
26	5 Yr 1 M	32	--	5	--	2.25	1	--	1.4	41.65
27	5 Yr 2 M	4.5	0.5	1.75	--	1.75	0.5	--	3.2	12.20

Figure 3. Total Abnormalities Per Bull for March 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	1.25	--	0.5	--	4.25	--	--	2.2	8.20
29	5 Yr 4 M	--	--	--	--	--	--	--	--	--
30	5 Yr 8 M	0.75	--	1.25	0.25	6.75	1	--	1.4	11.40
31	5 Yr 9 M	7.5	0.5	0.5	0.25	5.5	0.75	--	1.2	16.20
32	5 Yr 11 M	2.5	0.25	1.25	0.5	3	1	--	2.6	11.10
33	6 Yr	3.5	0.25	3	--	4	--	--	1.6	12.35
34	6 Yr 2 M	0.5	--	0.25	0.25	0.75	0.75	--	0.8	3.30
35	6 Yr 2 M	--	--	--	--	--	--	--	--	--
36	6 Yr 9 M	6	1.25	1.75	--	13.25	0.5	--	3.6	26.35
37	6 Yr 10 M	--	--	--	--	--	--	--	--	--
38	6 Yr 11 M	--	--	--	--	--	--	--	--	--
39	7 Yr	1.75	--	1.75	--	1.75	0.25	0.5	0.4	6.4
40	7 Yr 1 M	--	--	--	--	--	--	--	--	--
41	7 Yr 3 M	0.75	0.75	0.5	--	0.5	1	--	1.4	4.9
42	7 Yr 9 M	3.5	0.75	2.5	1	4.25	0.5	--	1.8	14.3
43	8 Yr 3 M	3.5	1	2.5	--	11.25	--	--	3.2	21.45
44	10 Yr	--	--	--	--	--	--	--	--	--

Figure 4. Total Abnormalities Per Bull for April 1977

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	--	--	--	--	--	--	--	--	--
2	8 M	--	--	--	--	--	--	--	--	--
3	9 M	--	--	--	--	--	--	--	--	--
4	10 M	--	--	--	--	--	--	--	--	--
5	10 M	--	--	--	--	--	--	--	--	--
6	1 Yr	--	--	--	--	--	--	--	--	--
7	1 Yr 1 M	2	4.25	0.5	--	1.5	0.5	--	0.4	9.15
8	1 Yr 1 M	2.5	0.25	1.25	0.25	1.5	3.25	--	0.6	9.60
9	1 Yr 3 M	--	--	0.75	0.5	0.25	0.5	--	0.8	2.80
10	1 Yr 9 M	1.5	1	--	--	3	--	--	0.6	6.10
11	1 Yr 9 M	1.5	3.5	0.5	0.5	1.5	--	--	1	8.50
12	1 Yr 10 M	11	3.5	3.25	0.5	5	1	2	4.2	30.45
13	1 Yr 11 M	4.5	2	--	--	0.25	0.25	--	0.4	7.4
14	2 Yr	--	0.25	0.5	0.5	1.25	0.25	--	1	3.75
15	2 Yr	2.25	2.5	--	--	2.75	0.75	--	2.2	10.45
16	2 Yr 4 M	8.25	0.75	1.25	--	1	0.5	--	1.4	13.15
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1	1.25	--	0.25	1.5	0.5	0.25	0.8	5.55
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	2	1.75	--	0.75	2.75	--	--	2.2	9.45
21	4 Yr 6 M	1	1.25	0.25	1.5	4.25	0.25	--	2	10.50
22	4 Yr 6 M	--	--	--	--	--	--	--	--	--
23	4 Yr 11 M	--	--	--	--	--	--	--	--	--
24	5 Yr	--	--	--	--	--	--	--	--	--
25	5 Yr	2.75	0.5	--	--	1.5	--	--	1.6	6.35
26	5 Yr 1 M	24.5	8.5	--	0.25	2	0.75	--	1	37
27	5 Yr 2 M	2.75	2.25	--	--	1.25	--	--	1	7.25

Figure 4. Total Abnormalities Per Bull for April 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	1.75	0.75	--	0.25	5.25	1.25	--	0.8	10.05
29	5 Yr 4 M	--	--	--	--	--	--	--	--	--
30	5 Yr 8 M	0.25	0.75	--	--	1.25	0.25	--	1	3.50
31	5 Yr 9 M	12.75	3.25	0.75	1.5	1	0.5	0.5	2.2	22.45
32	5 Yr 11 M	2	1.25	--	--	1.25	0.75	--	0.8	6.05
33	6 Yr	0.75	0.25	--	--	2.5	--	--	1.8	5.30
34	6 Yr 2 M	0.75	0.25	--	--	0.75	0.25	--	1.6	3.60
35	6 Yr 2 M	1.25	3	0.25	--	1	--	--	0.6	6.10
36	6 Yr 9 M	5	1.75	--	22.5	22.5	0.25	--	4.8	56.8
37	6 Yr 10 M	2	1.5	1	--	0.25	1.25	--	0.8	6.8
38	6 Yr 11 M	--	--	--	--	--	--	--	--	--
39	7 Yr	1	0.25	0.75	--	0.25	0.25	--	0.8	3.30
40	7 Yr 1 M	--	--	--	--	--	--	--	--	--
41	7 Yr 3 M	--	--	--	--	--	--	--	--	--
42	7 Yr 9 M	4.75	2.75	0.25	0.5	6	0.25	--	1.4	15.9
43	8 Yr 3 M	6.5	0.75	0.75	0.25	1.5	0.25	--	2.2	12.2
44	10 Yr	1.75	0.5	5	2	10.5	--	--	0.6	20.35

Figure 5. Total Abnormalities Per Bull for May 1977

Bull No.	Age at January 1977	Pro. Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	--	--	--	--	--	--	--	--	--
2	8 M	--	--	--	--	--	--	--	--	--
3	9 M	--	--	--	--	--	--	--	--	--
4	10 M	--	--	--	--	--	--	--	--	--
5	10 M	--	--	--	--	--	--	--	--	--
6	1 Yr	--	--	--	--	--	--	--	--	--
7	1 Yr 1 M	1	3	0.25	--	0.25	--	--	0.4	4.90
8	1 Yr 1 M	2.5	2.75	1	0.5	2.75	1	--	1	11.50
9	1 Yr 3 M	--	1.5	--	--	1	0.25	--	0.4	3.15
10	1 Yr 9 M	1.75	1	0.25	0.25	2.75	--	--	0.6	6.60
11	1 Yr 9 M	0.5	2.5	0.5	--	1	0.5	--	0.6	5.60
12	1 Yr 10 M	3.25	0.75	2.25	--	2.75	0.75	--	1.8	11.55
13	1 Yr 11 M	2	1.5	--	--	--	0.25	--	0.8	4.55
14	2 Yr	0.25	1.25	0.75	--	0.75	0.25	--	1.2	4.45
15	2 Yr	--	--	--	--	--	--	--	--	--
16	2 Yr 4 M	11	3.5	1.5	--	3.5	--	0.25	1.4	21.15
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1	1.75	0.5	--	0.75	1.25	--	0.4	5.65
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	2	1.5	0.25	0.25	4.5	--	--	2	10.5
21	4 Yr 6 M	5	5.75	5.25	--	26.25	0.25	--	1	43.5
22	4 Yr 6 M	--	--	--	--	--	--	--	--	--
23	4 Yr 11 M	--	--	--	--	--	--	--	--	--
24	5 Yr	--	--	--	--	--	--	--	--	--
25	5 Yr	2.5	0.75	0.25	--	--	0.25	--	1	4.75
26	5 Yr 1 M	30	2.75	8.5	0.5	4.5	--	--	3.2	46.25
27	5 Yr 2 M	2.5	1.75	--	--	--	--	--	2	6.25

Figure 5. Total Abnormalities Per Bull for May 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns.,(Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	1.5	0.75	--	0.5	1.75	0.5	--	0.6	5.60
29	5 Yr 4 M	--	--	--	--	--	--	--	--	--
30	5 Yr 8 M	1.25	0.75	0.25	0.25	3.5	--	--	3	9.0
31	5 Yr 9 M	3	23.5	1.75	--	0.25	4.5	0.25	1.2	34.45
32	5 Yr 11 M	--	--	--	--	--	--	--	--	--
33	6 Yr	--	--	--	--	--	--	--	--	--
34	6 Yr 2 M	--	--	--	--	--	--	--	--	--
35	6 Yr 2 M	1.25	2	1	--	2	--	--	0.6	6.85
36	6 Yr 9 M	4.5	3.5	0.25	--	15	0.25	--	2	25.50
37	6 Yr 10 M	0.75	0.75	0.25	--	1	0.25	--	0.4	3.40
38	6 Yr 11 M	--	--	--	--	--	--	--	--	--
39	7 Yr	0.75	1	--	0.25	0.5	0.75	--	0.8	4.05
40	7 Yr 1 M	--	--	--	--	--	--	--	--	--
41	7 Yr 3 M	0.75	--	--	--	0.5	0.25	--	1	2.50
42	7 Yr 9 M	2.5	5.25	0.25	--	10.75	0.25	--	1.2	20.2
43	8 Yr 3 M	4.25	--	--	--	0.25	0.25	--	2	6.75
44	10 Yr	2.5	2.25	--	1	4.75	0.25	--	0.8	11.55

Figure 6. Total Abnormalities Per Bull for June 1977

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	2.75	1	0.25	--	2	--	--	2.6	8.60
2	8 M	0.75	1.25	1	--	0.5	1.25	--	3.2	7.95
3	9 M	1.75	1	--	1	2	0.5	--	8.4	14.65
4	10 M	5.5	2.75	--	--	1.5	--	--	3.4	13.15
5	10 M	7	0.5	0.5	0.5	0.5	--	--	2.6	11.6
6	1 Yr	1.75	0.25	1.5	--	0.75	--	--	1.4	4.65
7	1 Yr 1 M	2	--	0.25	0.5	--	0.25	--	1	4
8	1 Yr 1 M	1	0.5	--	0.25	2.25	0.75	--	8.4	13.15
9	1 Yr 3 M	--	0.25	1	0.5	1.25	0.75	--	1.8	5.55
10	1 Yr 9 M	1.25	2	0.25	--	0.5	--	--	2	6.0
11	1 Yr 9 M	--	1.25	--	0.5	1	0.75	--	11.4	14.9
12	1 Yr 10 M	4.5	4	2.75	0.25	4.25	0.75	--	5.6	22.10
13	1 Yr 11 M	2.75	0.75	1	--	--	--	--	1.8	6.30
14	2 Yr	--	0.5	0.75	--	0.25	0.75	--	1.4	3.65
15	2 Yr	5.25	5	0.75	--	1.75	1	--	1.6	15.35
16	2 Yr 4 M	17.5	2.75	0.75	0.25	2.25	0.25	--	10.8	34.55
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1	3.25	1	0.25	1.25	1.25	--	0.8	8.80
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	6.25	12.5	1.5	0.25	3.5	0.5	--	11.8	36.3
21	4 Yr 6 M	8.5	4.25	2.75	--	29.5	0.5	--	1.4	46.9
22	4 Yr 6 M	--	0.75	0.5	--	0.5	0.5	--	3.4	5.65
23	4 Yr 11 M	0.75	0.25	--	0.25	0.25	0.5	--	4.6	6.60
24	5 Yr	8.25	1.5	3.25	1.25	3	--	--	17.4	34.65
25	5 Yr	2	1.5	0.25	--	0.5	1	--	9.2	14.45
26	5 Yr 1 M	--	--	--	--	--	--	--	--	--
27	5 Yr 2 M	4.25	0.75	0.25	--	0.5	0.5	--	4	10.25
28	5 Yr 3 M	0.5	2	0.25	0.25	1.75	0.5	--	2	7.25

Figure 6. Total Abnormalities Per Bull for June 1977 (continued)

Bull No.	Age at January 1977	Pro Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms,	Tail Abns.	Mid-Piece Abns., (Rough, Coiled, Double Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
29	5 Yr 4 M	1.75	2	0.5	0.25	2	0.25	—	2.2	8.95
30	5 Yr 8 M	0.5	0.25	0.75	1.25	0.75	0.5	—	4.8	8.80
31	5 Yr 9 M	5.75	5	1	0.25	2	0.5	—	0.4	14.90
32	5 Yr 11 M	1	1	--	--	1.75	--	--	6	9.75
33	6 Yr	1.25	3	1.25	--	2.75	0.5	—	4.8	13.55
34	6 Yr 2 M	--	--	--	--	--	--	--	--	--
35	6 Yr 2 M	1.75	2.5	0.25	--	1.25	1	--	1.4	8.15
36	6 Yr 9 M	7.75	16.25	0.75	0.75	21.25	0.25	--	2.8	49.8
37	6 Ur 10 M	0.75	1.5	0.25	--	1.5	0.75	--	0.4	5.15
38	6 Yr 11 M	1.75	2.75	--	1	0.75	0.5	--	18.4	25.15
39	7 Yr	1	1	--	--	0.5	0.25	--	1.4	4.15
40	7 Yr 1 M	5.5	0.25	0.5	--	6	0.5	--	3	15.75
41	7 Yr 3 M	0.75	--	0.5	--	0.75	--	--	2.8	4.80
42	7 Yr 9 M	12.25	8.25	—	0.25	14.5	1	--	2	38.25
43	8 Yr 3 M	2	2	3	0.5	0.75	0.5	--	9.4	18.15
44	10 Yr	4.75	4.25	0.75	1	3.5	0.25	—	2.4	16.9

Figure 7. Total Abnormalities Per Bull for July 1977

Bull No.	Age at January 1977	Pro. Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	4.25	1.25	0.25	0.5	1	0.75	--	2.6	10.6
2	8 M	1.25	0.5	0.25	--	0.5	--	--	6.4	8.9
3	9 M	1	3.5	0.25	--	2.75	--	0.5	2	10
4	10 M	3	1.25	--	0.5	1	0.25	--	5.8	11.8
5	10 M	5	2	--	1.25	0.75	1.75	--	4.4	15.15
6	1 Yr	4	1.5	0.25	--	2.5	--	--	0.6	8.85
7	1 Yr 1 M	2.25	1	0.25	0.25	--	--	--	2.6	6.35
8	1 Yr 1 M	2	0.5	--	--	2.25	0.75	--	2.4	7.90
9	1 Yr 3 M	0.25	2	0.25	--	0.5	0.25	--	1	4.25
10	1 Yr 9 M	0.75	0.5	0.75	0.25	2.25	--	--	1.4	5.90
11	1 Yr 9 M	0.25	1	--	0.25	2	0.5	--	3	7
12	1 Yr 10 M	2.25	1.25	1.75	--	3.75	1	--	2.2	12.2
13	1 Yr 11 M	2	1	0.5	0.5	0.5	0.75	--	1.6	6.85
14	2 Yr	0.25	1.5	1.5	0.25	0.25	--	--	1.4	5.15
15	2 Yr	2.75	4.25	2.25	--	11.75	1.75	--	2.8	25.55
16	2 Yr 4 M	11.25	1.5	2.75	--	6.5	--	--	8.4	30.40
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	0.75	0.5	0.25	0.75	4	0.5	--	2.4	8.65
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	5.5	8	0.5	0.75	19.25	1.25	--	5.8	41.05
21	4 Yr 6 M	6.5	4.75	2.25	0.5	45.5	--	--	4.2	63.7
22	4 Yr 6 M	--	--	0.5	--	1.5	0.5	--	1.6	4.1
23	4 Yr 11 M	1.5	0.75	0.5	--	0.75	--	--	3.2	6.7
24	5 Yr	9.25	2	--	0.75	6.5	1	--	1.2	20.7
25	5 Yr	2	0.75	--	0.25	1.25	--	--	4	8.25
26	5 Yr 1 M	--	--	--	--	--	--	--	--	--
27	5 Yr 2 M	4	1	1	--	1	--	--	12.6	19.6

Figure 7. Total Abnormalities Per Bull for July 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	3.5	2	0.5	--	6.5	0.5	--	2.2	15.2
29	5 Yr 4 M	3	1.25	--	0.5	1.25	0.25	--	3	9.25
30	5 Yr 8 M	1	0.25	0.75	--	1.25	0.5	--	7.2	10.95
31	5 Yr 9 M	6	3.5	0.25	1.75	2	1.25	1.25	1.2	17.2
32	5 Yr 11 M	2	1.25	0.75	--	1.25	--	--	6.2	11.45
33	6 Yr	0.5	0.75	--	--	0.5	0.75	--	1.2	3.7
34	6 Yr 2 M	--	--	--	--	--	--	--	--	--
35	6 Yr 2 M	1.75	1.75	0.5	--	2.5	0.75	--	1.4	8.65
36	6 Yr 9 M	3.75	0.75	--	--	15.5	0.25	--	15.6	35.85
37	6 Yr 10 M	1.75	0.75	0.25	--	0.75	0.5	--	1.2	5.2
38	6 Yr 11 M	2.25	1.75	0.25	--	0.75	0.25	--	4.4	9.65
39	7 Yr	2.25	1.75	0.25	--	0.75	0.25	--	4.4	9.65
40	6 Yr 1 M	3.5	3.75	--	--	2.5	0.25	--	0.4	10.4
41	7 Yr 3 M	1.5	--	--	0.5	1	1	--	1.2	5.2
42	7 Yr 9 M	6.5	7	1	0.75	21.25	0.5	--	1.8	38.8
43	8 Yr 3 M	8.25	5	2	--	8.5	1	--	13	37.75
44	10 Yr	2.5	8	2	0.5	2.25	0.75	--	0.6	16.6

Figure 8. Total Abnormalities Per Bull for August 1977

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	2.5	0.25	0.25	0.5	0.25	0.25	--	2.6	6.60
2	8 M	0.25	--	--	0.25	3	--	--	1.2	4.70
3	9 M	2.5	0.5	0.5	--	1.75	0.25	--	2.4	7.9
4	10 M	3.5	1.25	--	0.25	2.75	--	--	1.2	8.95
5	10 M	3	--	0.25	--	2.5	--	--	3.6	9.35
6	1 Yr	1.75	1.75	0.25	0.25	1.75	0.25	--	1	6.0
7	1 Yr 1 M	2.5	0.25	0.5	1	0.75	--	--	1.8	6.8
8	1 Yr 1 M	1	--	0.25	0.75	3.25	0.25	0.25	1.6	7.35
9	1 Yr 3 M	0.75	--	0.5	--	1.5	--	--	0.8	3.55
10	1 Yr 9 M	0.75	0.75	--	--	3.75	--	--	0.6	5.85
11	1 Yr 9 M	0.75	--	0.75	--	1.5	0.5	--	1.2	4.7
12	1 Yr 10 M	4.5	0.5	0.25	--	3.5	--	--	0.4	9.15
13	1 Yr 11 M	3	--	0.25	0.25	1	0.5	--	1	6.00
14	2 Yr	0.25	0.5	1	--	1.25	--	--	0.4	3.40
15	2 Yr	2.25	0.75	0.25	--	4.25	0.5	--	4.2	12.2
16	2 Yr 4 M	5.25	1.5	0.5	--	1.25	--	--	2.4	10.9
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	--	--	--	0.25	1	--	--	1.4	2.65
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	2.5	1.75	0.5	1	3.25	0.25	--	5.4	14.65
21	4 Yr 6 M	6.5	3	4	0.25	45.25	0.25	--	2.4	61.65
22	4 Yr 6 M	--	0.25	0.25	--	1.25	--	--	0.4	2.15
23	4 Yr 11 M	0.5	0.5	0.25	0.25	0.75	--	--	0.2	2.45
24	5 Yr	68.25	--	0.5	0.25	4.25	0.5	--	7	80.75
25	5 Yr	2.5	0.25	--	0.5	1.5	--	--	0.8	5.55
26	5 Yr 1 M	--	--	--	--	--	--	--	--	--
27	5 Yr 2 M	2.75	1.75	--	0.25	0.25	--	--	0.4	5.4

Figure 8. Total Abnormalities Per Bull for August 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	0.5	0.75	--	--	14.75	0.25	--	0.6	16.85
29	5 Yr 4 M	1.75	1	--	--	1.25	--	--	0.6	4.60
30	5 Yr 8 M	0.25	0.25	--	0.5	0.75	--	--	1	2.75
31	5 Yr 9 M	1.25	--	0.75	0.25	12.75	0.25	--	0.8	16.10
32	5 Yr 11 M	0.75	0.75	0.75	--	1	0.25	--	2.2	5.70
33	6 Yr	2	0.25	1	--	2.5	0.25	--	1	7
34	6 Yr 2 M	0.75	0.75	1.25	0.75	0.5	--	0.25	0.6	4.85
35	6 Yr 2 M	5.25	--	0.25	--	4	--	--	0.4	9.90
36	6 Yr 9 M	4.75	0.75	0.25	--	15	--	--	4.2	24.95
37	6 Yr 10 M	0.75	1	0.25	0.25	1.25	--	--	0.4	3.80
38	6 Yr 11 M	1.75	2.75	0.25	--	1	--	--	0.8	6.55
39	7 Yr	0.25	1.25	--	0.5	0.5	--	0.25	1.2	3.95
40	7 Yr 1 M	6	0.25	--	--	0.25	--	--	0.4	6.90
41	7 Yr 3 M	0.25	0.75	0.5	0.5	0.75	--	--	1	2.75
42	7 Yr 9 M	3	0.75	0.25	0.25	15.5	--	--	0.6	19.75
43	8 Yr 3 M	18.5	13.5	7	0.25	3.5	--	--	17.6	60.35
44	10 Yr	3.75	1.5	0.5	0.5	1.25	--	--	2.2	9.70

Figure 9. *Total Abnormalities Per Bull for September 1977*

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	2	1	0.25	--	0.75	0.5	--	1.8	6.3
2	8 M	0.5	--	0.5	--	0.25	0.25	--	0.6	2.1
3	9 M	1.25	0.5	0.5	--	0.5	--	--	1.4	4.15
4	10 M	1.75	2.5	0.25	--	2.5	--	--	1.4	8.4
5	10 M	2.25	1.75	--	0.25	0.75	0.25	--	1.4	6.65
6	1 Yr	1.25	0.5	1	--	2	0.25	--	0.8	5.8
7	1 Yr 1 M	1.5	2.25	--	0.25	0.75	0.25	--	2.6	7.6
8	1 Yr 1 M	1.5	1.75	--	--	2	1.75	--	0.6	7.6
9	1 Yr 3 M	--	1	0.5	--	0.5	--	--	1	3.0
10	1 Yr 9 M	1	1	0.5	--	0.25	0.5	--	0.4	3.65
11	1 Yr 9 M	0.5	6.75	0.25	0.25	1.75	--	--	1.4	10.9
12	1 Yr 10 M	3	--	0.5	0.5	2.75	0.5	--	3	10.25
13	1 Yr 11 M	1	1	--	0.5	1	--	--	1.2	4.7
14	2 Yr	--	0.25	0.75	0.25	1.25	--	--	0 6	3.1
15	2 Yr	1.25	2.25	1.25	--	2	1	--	2.8	10.55
16	2 Yr 4 M	7.5	3.25	1	--	0.75	0.25	--	3.4	16.15
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1.75	1.25	0.25	--	1.25	0.25	--	1.6	6.35
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	4.5	1.75	0.5	0.25	2.25	--	--	2.8	12.05
21	4 Yr 6 M	5.25	6.5	7	0.25	38.25	--	0.75	3.6	61.60
22	4 Yr 6 M	--	0.25	1	1	1	--	--	1.8	5.05
23	4 Yr 11 M	--	2	--	--	1.5	0.25	--	1.6	5.35
24	5 Yr	15.75	6	0.25	--	6.75	0.25	--	5.8	34.8
25	5 Yr	3.25	0.75	0.5	--	1	--	--	0.8	6.30
26	5 Yr 1 M	--	--	--	--	--	--	--	--	--
27	5 Yr 2 M	2.5	1.25	0.25	--	--	--	--	1.2	5.20

Figure 9. Total Abnormalities Per Bull for September 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	0.75	0.75	0.25	0.75	1.5	--	--	1.6	5.60
29	5 Yr 4 M	1.5	0.75	0.75	--	0.25	0.5	--	1	4.75
30	5 Yr 8 M	1.5	--	0.25	0.25	0.25	0.25	--	4.8	7.05
31	5 Yr 9 M	6.25	2.25	0.25	0.5	0.5	--	--	1.2	10.95
32	5 Yr 11 M	0.75	0.75	0.75	0.5	0.75	--	--	2.2	5.70
33	6 Yr	2	1.25	1.25	--	2	--	--	1.2	7.70
34	6 Yr 2 M	0.25	1.25	1	--	1.75	0.25	--	2.4	6.90
35	6 Yr 2 M	2.25	0.25	0.25	0.5	1	--	--	0.8	5.05
36	6 Yr 9 M	6.5	2.75	5	--	17.75	--	--	5.5	37.50
37	6 Yr 10 M	1	0.75	--	--	0.75	--	--	1	3.5
38	6 Yr 11 M	3.25	2.75	--	--	1	0.5	--	2.2	9.7
39	7 Yr	--	0.25	0.25	--	0.75	--	--	1.2	2.45
40	7 Yr 1 M	5.75	2.25	--	0.5	0.5	--	--	1.8	10.80
41	7 Yr 3 M	0.5	0.5	--	--	1	--	--	0.4	2.4
42	7 Yr 9 M	4.25	2.25	0.5	--	7.5	--	--	1.8	16.3
43	8 Yr 3 M	3.5	2.75	6.25	--	3.5	0.5	--	9	25.50
44	10 Yr	3.75	3.25	1.75	0.5	1.75	--	--	1	12.00

Figure 10. Total Abnormalities Per Bull for October 1977

Bull No.	Age at January 1977	Pro. Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	2.75	0.5	--	0.5	1.25	--	--	1.4	6.4
2	8 M	1	1	0.25	0.75	1.5	--	--	0.6	5.1
3	9 M	1	1.5	0.5	0.5	1.75	0.25	--	0.6	6.1
4	10 M	4.5	1.5	0.25	1	0.75	1	--	0.8	9.8
5	10 M	1.75	2	--	0.5	0.5	1	--	1.4	7.15
6	1 Yr	0.25	1.5	0.25	0.25	1.5	0.5	--	0.4	4.7
7	1 Yr 1 M	--	0.5	--	--	1	0.25	--	0.4	2.1
8	1 Yr 1 M	1.75	0.25	0.25	0.25	1.25	1.25	--	1.4	6.4
9	1 Yr 3 M	1	1.75	--	0.25	2.25	1.5	--	2	8.75
10	1 Yr 9 M	1	2.5	0.5	--	0.75	0.5	--	1.6	6.85
11	1 Yr 9 M	0.25	0.5	--	--	0.75	0.5	--	1.6	3.60
12	1 Yr 10 M	7.25	--	2.75	0.25	3.75	1.5	--	2.4	17.9
13	1 Yr 11 M	4.5	0.25	--	0.5	0.75	--	--	1.8	7.8
14	2 Yr	0.5	0.25	0.25	0.5	6.25	--	--	3.2	10.95
15	2 Yr	1.25	5.5	1.25	0.75	5.5	0.25	--	2.8	17.3
16	2 Yr 4 M	11	--	2	0.25	1.5	--	--	7.6	22.4
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	1.5	4	0.75	0.25	1.25	0.5	--	1.6	9.85
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	4.5	5.25	--	0.75	7.5	1.75	--	4.4	24.15
21	4 Yr 6 M	3.75	3.25	2.5	--	19.5	0.75	--	6.2	35.95
22	4 Yr 6 M	0.25	0.25	1.5	0.25	1	0.25	--	1.6	5.1
23	4 Yr 11 M	1.75	3	--	--	0.5	0.75	--	2.4	8.4
24	5 Yr	7.75	2.75	--	--	6	1.5	--	4.6	22.6
25	5 Yr	0.25	1.25	0.25	0.25	0.75	0.5	--	1.0	4.25
26	5 Yr 1 M	--	--	--	--	--	--	--	--	--
27	5 Yr 2 M	1.75	5.5	2	0.25	1	--	--	1.4	11.9

Figure 10. Total Abnormalities Per Bull for October 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	1.25	1.5	0.75	0.25	1.75	0.75	--	1	7.25
29	5 Yr 4 M	1.25	3	--	0.5	0.5	--	--	1.4	6.65
30	5 Yr 8 M	0.75	0.25	0.25	0.75	1.5	0.25	--	1	4.75
31	5 Yr 9 M	5	6	0.25	0.25	2.25	1	--	1.2	15.95
32	5 Yr 11 M	1.25	25.75	1.25	--	6	0.25	--	3	37.5
33	6 Yr	0.75	1.5	0.25	0.5	2.5	0.5	--	2.6	8.6
34	6 Yr 2 M	0.5	0.75	1	0.5	0.5	--	--	3	6.25
35	6 Yr 9 M	--	--	--	--	--	--	--	--	--
36	6 Yr 9 M	--	--	--	--	--	--	--	--	--
37	6 Yr 10 M	1.25	1.25	1.5	--	0.5	0.5	--	0.6	5.60
38	6 Yr 11 M	4.25	3.25	0.25	--	4.25	0.25	--	5.6	17.85
39	7 Yr	0.75	1.25	0.25	--	0.25	0.5	--	1.6	4.6
40	7 Yr 1 M	4.5	2.25	0.5	--	1.75	0.5	--	1.6	11.10
41	7 Yr 3 M	0.75	0.75	0.25	--	4	0.25	--	0.6	6.60
42	7 Yr 9 M	7.5	7	0.75	1	6	1	--	1.8	25.05
43	8 Yr 3 M	2.5	0.25	1.25	0.25	1.25	0.5	--	4.8	10.80
44	10 Yr	5.25	3	--	0.25	1.5	0.25	--	1.2	11.45

Figure 11. Total Abnormalities Per Bull for November 1977

Bull No.	Age at January 1977	Pro. Cyt. Droplets	Distal Cyt. Droplets	Tailless Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	2.25	2	0.5	0.5	1	0.25	--	1.2	7.7
2	8 M	0.25	1.5	0.5	0.25	0.25	0.25	--	1.8	4.8
3	9 M	1.4	0.8	0.6	0.2	2.1	0.2	--	0.6	5.9
4	10 M	3	1.25	--	0.75	3	1.25	--	1.4	10.65
5	10 M	3	0.75	0.5	0.5	0.25	--	--	1.6	6.6
6	1 Yr	1.75	1	0.75	0.5	2.25	0.25	--	1.2	7.95
7	1 Yr 1 M	0.75	0.5	0.5	0.25	1.25	--	--	0.6	3.85
8	1 Yr 1 M	0.75	0.75	0.25	0.25	2.5	0.5	--	0.4	3.15
9	1 Yr 3 M	--	0.5	--	0.25	1	0.5	--	0.8	3.05
10	1 Yr 9 M	0.25	0.25	0.5	1	1.25	0.75	--	2	6
11	1 Yr 9 M	0.5	--	1.5	--	1.5	0.25	--	1.8	5.55
12	1 Yr 10 M	6	1	3.75	--	3.5	1	--	3.2	18.45
13	1 Yr 11 M	2.75	0.75	0.25	0.25	1.25	0.25	--	0.4	5.9
14	2 Yr	0.75	0.25	1.25	--	0.75	0.25	--	2.2	5.45
15	2 Yr	1.25	4	1.25	0.5	2.25	0.25	--	1.8	11.3
16	2 Yr 4 M	6.5	3.5	1.25	0.75	2	0.25	--	2.6	16.85
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	0.5	--	0.75	0.75	1	0.75	--	0.4	4.15
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	4.5	5.25	0.5	1	6.5	--	--	3	20.75
21	4 Yr 6 M	5.25	6.5	1.75	0.5	30	0.25	--	2	44.25
22	4 Yr 6 M	0.25	0.75	0.75	0.5	1.25	--	--	3.8	7.30
23	4 Yr 11 M	2	2	0.5	1.25	1.5	--	--	0.4	7.65
24	5 Yr	4	1.75	0.25	--	2.25	0.75	--	1.2	10.2
25	5 Yr	1.5	1	1.25	0.75	0.5	--	--	1.4	6.4
26	5 Yr 1 M	--	--	--	--	--	--	--	--	--
27	5 Yr 2 M	1.5	2.25	0.25	0.75	0.75	0.25	--	1.4	6.9

Figure 11. Total Abnormalities Per Bull for November 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	--	1.25	0.5	0.25	1.5	0.25	--	0.8	4.55
29	5 Yr 5 M	2.5	2.5	--	0.25	2.5	0.25	--	1.2	9.2
30	5 Yr 8 M	2.5	16.75	0.5	0.75	1.25	0.25	--	1.8	23.8
31	5 Yr 9 M	2.75	5.5	0.25	--	2.75	0.25	--	1.2	12.7
32	5 Yr 11 M	0.75	2.25	0.25	--	1.75	--	--	1.6	6.6
33	6 Yr	0.75	1.75	0.25	--	5	--	0.25	0.6	8.6
34	6 Yr 2 M	0.5	0.75	0.5	0.25	1.5	0.25	--	0.8	4.55
35	6 Yr 2 M	--	--	--	--	--	--	--	--	--
36	6 Yr 9 M	--	--	--	--	--	--	--	--	--
37	6 Yr 10 M	2.5	2	--	0.25	1	--	--	0.4	6.14
38	6 Yr 11 M	2.5	1.5	1	--	1	--	--	1	7
39	7 Yr	0.75	0.5	0.5	--	2.25	--	--	1	5
40	7 Yr 1 M	4.75	3.25	0.25	0.25	2	--	--	0.4	10.9
41	7 Yr 3 M	0.5	0.5	1	0.25	2.25	0.5	--	1.4	6.4
42	7 Yr 9 M	3.75	4.25	0.5	1.25	7	0.75	--	1	17.5
43	8 Yr 3 M	2.75	3	--	--	9	--	--	1.4	16.15
44	10 Yr	3	6	--	0.5	2.5	--	--	1.8	13.8

Figure 12. Total Abnormalities Per Bull for December 1977

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
1	7 M	1.75	0.5	0.5	0.25	2	0.75	--	1.8	7.55
2	8 M	0.5	0.75	1	0.25	0.75	0.5	--	2	5.75
3	9 M	3.25	0.5	--	--	1.25	0.5	--	1.2	6.7
4	10 M	1.75	1.75	0.25	--	1.5	--	--	1	6.25
5	10 M	2	2	0.25	0.25	0.25	--	--	2.6	7.35
6	1 Yr	0.75	5	0.5	0.5	0.75	0.25	0.25	0.6	8.60
7	1 Yr 1 M	1	4	0.5	--	0.75	--	--	0.6	6.85
8	1 Yr 1 M	1.5	--	--	--	2.5	0.25	--	0.8	5.05
9	1 Yr 3 M	0.25	0.75	0.75	0.5	2	0.25	--	1.4	5.90
10	1 Yr 9 M	1.75	1.5	0.5	--	1.5	0.25	--	0.8	6.30
11	1 Yr 9 M	0.25	8.25	0.75	0.5	1	--	--	2.6	13.35
12	1 Yr 10 M	10.5	0.75	2.5	--	1.25	0.75	--	5.6	21.35
13	1 Yr 11 M	3.5	0.5	0.25	--	0.5	--	--	1	5.75
14	2 Yr	0.75	1.5	0.25	0.25	1	--	--	0.6	4.35
15	2 Yr	1.75	5	--	0.25	1.25	--	--	2.2	10.45
16	2 Yr 4 M	5.75	3.5	--	--	1.25	--	--	3.8	14.30
17	2 Yr 5 M	--	--	--	--	--	--	--	--	--
18	2 Yr 11 M	0.25	0.25	--	0.25	2.25	0.25	--	0.6	3.85
19	3 Yr	--	--	--	--	--	--	--	--	--
20	3 Yr 11 M	3.25	5.25	0.5	1.25	3.25	--	0.25	3.2	16.95
21	4 Yr 6 M	4.25	5.5	1.75	0.25	17	0.25	--	4.8	33.8
22	4 Yr 6 M	1.5	0.5	0.5	--	1	--	--	0.6	4.1
23	4 Yr 11 M	1.25	1.75	--	0.5	1	0.5	--	0.8	5.8
24	5 Yr	3.25	1.5	--	0.25	1.75	0.25	--	1.6	8.6
25	5 Yr	1.5	--	--	--	2.75	1	--	0.6	5.85
26	5 Yr 1 M	--	--	--	--	--	--	--	--	--
27	5 Yr 2 M	2.25	1.25	0.25	0.75	0.75	--	--	1.2	6.45

Figure 12. Total Abnormalities Per Bull for December 1977 (continued)

Bull No.	Age at January 1977	Pro. Cyt. Drop-lets	Distal Cyt. Droplets	Tail-less Heads	Acrosomes Abnorms.	Tail Abns.	Mid-Piece Abns., (Rough Coiled, Double, Swollen)	Abaxial Attachment of Mid-Piece	Head Morph. Abnorms.	Total Abn. Per Bull
28	5 Yr 3 M	0.25	0.5	--	--	2.75	--	0.25	0.8	4.55
29	5 Yr 4 M	2.25	3	0.25	--	1.25	--	--	2.2	8.95
30	5 Yr 8 M	0.75	0.75	0.5	0.5	1	0.5	--	1.4	5.4
31	5 Yr 9 M	4	6	--	--	1.75	0.5	--	1.4	13.65
32	5 Yr 11 M	0.5	0.25	--	0.25	7	--	--	1.4	9.40
33	6 Ur	1.5	2.75	0.5	--	4.25	--	--	1.2	10.2
34	6 Ur 2 M	0.25	0.75	1	0.5	0.75	0.5	--	2	5.75
35	6 Ur 2 M	--	--	--	--	--	--	--	--	--
36	6 Yr 9 M	--	--	--	--	--	--	--	--	--
37	6 Yr 10 M	8.25	2.25	--	--	1	0.25	--	1.2	12.95
38	6 Ur 11 M	5	3	--	--	0.75	--	--	1	9.75
39	7 Yr	0.75	0.75	0.5	0.5	1.75	0.5	--	0.4	5.15
40	7 Yr 1 M	6	3	0.75	--	4.75	0.5	--	0.6	15.6
41	7 Yr 3 M	1	0.8	0.6	0.4	1.8	1.4	--	4.8	10.8
42	7 Yr 9 M	3	2	--	0.25	3.25	0.5	0.25	1.8	11.05
43	8 Yr 3 M	4.5	10.25	--	0.25	1.25	0.25	--	3.8	20.3
44	10 Yr	3.25	1.25	0.25	1.25	1.75	0.25	--	1.2	9.2

Staining Solutions

Carbolfuchsin (Williams Stain)

Stock solution: 10 g of fuchsin, 100 g of 96% alcohol. For mixing staining solution: 10 g of the stock solution, 100 g of 5% phenol solution. For staining use 50 cc of this mixture and 25 cc of saturated alcohol solution of bluish eosin. This mixture should stand for at least 14 days and when used for staining be filtered directly on the smear.

Loffler's methylene-blue.

Stock solution: 10 g of methylene-blue, 100 g of 96% alcohol. For mixing staining solution: 30 g of stock solution, 100 g of 0.01 % potassium hydroxide. The mixture is diluted with distilled water to 1/3 when used for staining.

Saturated alcoholic solution (96%) of eosin bluish.

Buffered Formal Saline

$Na_2HPO_4 \cdot 2H_2O$	6.19 g
KH_2PO_4	2.54 g
Formalin (38% formaldehyde)	125 ml
NaCl	5.41 g
Distilled H_2O	100 ml
Antibiotics	
Streptomycin	150 µg/ml
Penicillin	5000 units/ml