

Artificial insemination practice in Nigeria – review of the dangers of disease transmission

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Abstract

The first documented cattle artificial insemination (AI) in Nigeria dated back to 1949. Other recorded cattle artificial insemination in the country could be traced to when the Federal Government of Nigeria under the auspices of Ahmadu Bello University, Zaria, established Artificial Insemination Unit at the National Animal Production Research Institute (NAPRI) in 1976. Various limiting factors and constraints that prevented artificial insemination from being popular in the country were mentioned. Various causes of infertility in animals were listed. The success or failure of artificial insemination practice as could be affected by microorganisms in the semen, semen preservatives, semen extenders and storage temperatures were discussed in relation to work already done in Nigeria and other countries.

Keywords: Artificial insemination, semen, diseases, livestock

Introduction

Artificial insemination practice in Nigeria

Artificial insemination (AI) can be defined as the process whereby semen is collected from the male and transferred either as fresh or preserved material into a recipient. Originally, artificial insemination was developed in domestic animals in Europe to prevent the spreading of venereal diseases, to preserve animals that were almost in extinction and to obtain offspring from animals which were kept on small farms separated by long distances. Artificial insemination in developed countries has been used for game and wild animals, fish and other aquatic fauna, human beings, bees, etc (Perry, 1968).

The first documented artificial insemination in cattle in Nigeria was carried out at the Livestock Improvement Centre, Vom in August 1949 using imported bull semen. Other reports on artificial insemination in Nigeria could be

found in the Annual Report of the Livestock Investigation Centre, Vom. The report indicated that thirteen Friesian x Zebu calves were born following the artificial insemination (Annual Report, DVR, 1952-53).

Artificial insemination was also practised routinely at the Agege Dairy Farm, Lagos State in the sixties and early 70's where Friesian cows were maintained. Also artificial insemination had been practised on a small scale and for a short time at Iwo Road Dairy, Ibadan, Oyo State; Fashola Stock Farm near Oyo; and University of Ibadan Teaching and Research Farm (Osinowo, 1980).

The main objectives of artificial insemination as practised by these farms were to control diseases in the Government and Institutional farms as well as produce cross-bred animals for distribution to other Livestock Investigation and Breeding Centres (LIBCs) and to a few interested local individuals. This continued

until 1976 when the Decree Promulgating National Animal Production Research Institute (NAPRI), Shika, Zaria was enacted.

Artificial Insemination Unit was established as a service Unit at the National Animal Production Research Institute (NAPRI) under the auspices of Ahmadu Bello University (A.B.U), Zaria, and it received a Federal Government mandate to: (a) service the states artificial insemination programmes, (b) train inseminators, (c) collect and distribute semen from genetically promising bulls, (d) import semen from overseas and distribute to the states and (e) serve as a record centre for artificial insemination activities, (f) be responsible for the introduction and extension of artificial insemination services in the States and Federation.

The first documented insemination was carried out by Artificial Insemination Unit of NAPRI on the 16th January 1978 using locally processed chilled semen collected from a Sokoto Gudali bull three days prior to insemination (Voh, 1990). Bull semen for artificial insemination was also imported from Britain, Holland, U.S.A and Sweden. Rotary Club International, Zaria and International Bull Semen Donation Scheme of FAO also made semen donations.

As a result of NAPRI initiative to re-activate, maintain and expand artificial insemination practice in Nigeria, artificial insemination is now gaining grounds on government and some private farms in the country (Table 1).

Table 1 Number and distribution of artificial inseminations in cattle carried out in eleven states of Nigeria from 1979 to 1989

State	No. of cattle inseminated
Borno	500
Gongola	200
Kaduna	3200
Kano	80
Sokoto	30
Plateau	25
Niger	20
Bendel	195
Bauchi	30
Benue	7
Kwara	25

Source: A. A. Voh *Jar* (1990).

Apart from artificial insemination in cattle, extensive work has also been done on sheep using artificial insemination techniques of NAPRI. There are other researchers at Ibadan and Nsukka Universities who have worked on semen preservation using different extenders and preservatives to store semen of boars, rams, bucks and poultry (Osinowo *et al.*, 1980;

Azubuiké and Orji, 1983; Ahmed, 1989; Butswat, 1989).

The development of techniques for frozen livestock and wild animal semen, new therapeutic methods for the control of oestrus and ovulation and ability to ship semen across the globe have made artificial insemination practice a reality.

The advantages of artificial insemination

The development of techniques for frozen livestock and wild animal semen, new therapeutic methods for the control of oestrus and ovulation and ability to ship semen across the globe have made artificial insemination practice a reality. The benefits of artificial insemination include: Utilisation of proven sires. The danger, labour and expense of keeping inferior male is easily eliminated. Bulls are selected carefully and scientifically. With the advent of frozen semen, selection of bulls and line breeding is possible. Eliminates injury from incompatibility in size. It extends the usefulness of proven sires that for some physical reason or age are unable to copulate normally. It is an important tool in keeping males of monogamous species (eg. fox) or in hybridisation experiments where natural mating cannot take place. It is of value in shy, or easily frightened animals where there is lack of libido associated with sexual inexperience or pathological reasons including premature erection or prevention of intromission. Artificial insemination is useful in situation where females are in true oestrus and ovulate

but refuse to stand or accept the male. It may be used to control infectious diseases.

Disadvantages of artificial insemination

Well-trained personnel are needed for every stage of it. It is not a panacea for overcoming all infections or abnormalities of the female genital. Intrauterine insemination of a pregnant female may lead to abortion, pyometra or maceration of the foetus. Uncontrolled or unscrupulous operators or owners could substitute sperm of inferior quality unless bacteriological testing is routinely carried out before and after sperm collection from a herd or flock. Artificial insemination cannot be used freely on all species or breeds of animals or birds. In some species, a lot of preliminary work is required for successful artificial insemination.

Apart from the prophylactic significance of artificial insemination in the prevention of diseases, the overall success of artificial insemination is dependent on the reproductive success of the cattle stock and the quality of semen employed. Although extensive investigations have been carried out in Nigeria on the quality of semen, there is scanty literature on the danger of diseases transmission through which is the main thrust of this paper.

Table 2 Different factors that could be responsible for infertility in farm animals

1.	Specific Infections (Genital Diseases)
a)	Bovine Virus Diarrhoea
b)	Brucellosis
c)	Campylobacteriosis
d)	Chlamydiosis
e)	Epididymitis-vaginitis (EPIVAG)
f)	Infectious Bovine Rhinotracheitis/Infectious Pustular Vulvo Vaginitis (IBR/IDV)
g)	Leptospirosis
h)	Toxoplasmosis
i)	Trichomoniasis
j)	Trypanosomosis
k)	Others: Listeriosis, Rift Valley Fever, Wesselsbron Disease etc.
2.	Non Infectious Causes
a)	Age of the animal
b)	Anomalies of the genital tract
c)	Breed difference
d)	Milk yield
e)	Nutritional factors: level of nutrition; toxic plants and management
f)	Ovarian abnormalities (cystic, atrophic and hypoplastic ovaries)
g)	Poor detection of oestrus
h)	Season and ambient temperature
i)	Suckling
j)	Ability to preserve, store and deliver a dose of healthy semen at the right time to individual animals.
k)	Solar radiation together with humidity and velocity of the wind temperature - humidity index also have an influence on thawing of semen.

Source: Done *et al.*, (1980); Kahrs (1981); Vandeplassche (1982); Chauhan *et al.*, (1984); Hansel and Alila (1984); Rekwot *et al.*, (1987); Voh *et al.*, (1987); Sckoni *et al.*, (1988).

Factors limiting artificial insemination programme in Nigeria

Artificial insemination is not popular among the peasant farmers in many parts of the country for the following reasons:

- a) Type of animal husbandry practice among the nomadic and semi-nomadic Fulanis. The nomads move from place to place in search of feed and water throughout the whole year and more especially during the dry season. This would not allow for rapid adoption of artificial insemination.
- b) Inadequate attention being given to the development of livestock industry

compared to crops (arable and cash) greatly limited the use of artificial insemination.

- c) Lack of education with respect to the usefulness of artificial insemination has contributed to the slow development of artificial insemination practices.
- d) Frequent breakdown of liquid nitrogen plant because of power failure or non-availability of liquid nitrogen.
- e) Lack of incentive to artificial insemination workers in terms of transport and overtime.

- f) Improper heat detection and lack of adequate record by private cattle owners
- g) Difficulties of obtaining the necessary equipment, laboratory supplies and skilful personnel.

Diseases and Artificial Insemination

For animal production, a high reproductive output is a basic requirement. One of the immediate solutions to enhance a high animal production is by adopting artificial insemination.

Many large private farmers and government farms in Nigeria still import bulls and dairy animals to improve the genetic potential of their herds in order to boost meat and milk production. It is expensive besides the risk of introducing disease. The same objective could be achieved through artificial insemination.

Apart from the merits and demerits of artificial insemination enumerated above, infertility in farm animals could also be caused by other factors enumerated in Table 2. Although antibiotics used in different sperm extenders will eliminate a few bacteria in preserved semen (frozen or unfrozen) such as some *Campylobacter* spp. (*Vibrio* spp.) and reduce the numbers of certain susceptible bacteria such as Streptococci and Staphylococci. But it will not eliminate organisms such as *Brucella* sp., *Campylobacter* sp., *Trichomonas* sp., *Trypanosome vivax*, *Mycoplasma* sp., *Corynebacterium pyogenes*, *Listeria monocytogenes* and viruses such as: IBR-IDV, *Chlamydia*, Epivag and others (Cottral *et al.*, 1968; Adegboye and Kumi-Diaka, 1979; Sellers, 1983; Bawa *et al.*, 1987; Meyling and Jensen, 1988). Also mycotic such as *Aspergillus flavus*, *Aspergillus niger* and *Absidia* sp. can withstand the freezing temperature used for keeping semens. Various investigators (Eze, 1977; Eze, 1978; Adegboye and Kumi-Diaka, 1979; Bale and Kumi-Diaka, 1981; Hare, 1985; Bawa *et al.*, 1987; Wrathall, 1987) have isolated some of these pathogens from semen, milk and egg and milk and eggs are used as

sperm extender and preservatives (Osinowo *et al.*, 1980; Ahmed, 1989).

In Nigeria. Brucellae organisms have been isolated from the semen of cattle and milk (Bale and Kumi-Diaka, 1981). Also, isolates of *Brucella melitensis* have been obtained from sheep and goats milk (Bale, Addo and Nuru, 1981). Bawa *et al.*, (1987) isolated *Campylobacter* sp. from artificial insemination animals in Nigeria. Ezeh (1979) have isolated six new serovars of *Leptospira* sp. from male trade cattle at Jos abattoir. Also, Akinboade (1980) demonstrated serologically the prevalence of trichomoniasis (*Trichomonas fetus*) in female cattle in Nigeria.

Bacterial Diseases Transmitted Through Artificial Insemination

Brucellosis - Extensive studies were done on semen brucellosis by Eze (1978) and Bale and Kumi-Diaka (1981).

Tuberculosis - Rauby (1966) reviewed in great details the effect of tuberculosis on semen and transmission of tuberculosis to animals when such semen was used for artificial insemination. Not much of such work had been carried out in Nigeria.

Leptospirosis - Natural service sires may be distributors of *Leptospira* infection. Ezeh (1979) have isolated six new serovars of *Leptospira* sp. from male trade cattle at Jos abattoir. But the diagnosis of carriers by serology is not reliable (Ellis *et al.*, 1981) and treatment is not always very effective (Ellis *et al.*, 1985).

Trichomoniasis- Although bovine trichomoniasis is no longer prominent in the disease hierarchy, it is still present in cattle ranch worldwide perpetuated by natural service. Akinboade (1980) demonstrated serologically the prevalence of trichomoniasis (*Trichomonas fetus*) in female cattle in Nigeria. Bale (1984) also demonstrated that trichomonas can survive in liquid nitrogen temperature (-176°C).

Mycoplasmosis - *Mycoplasma mycoides* var *mycoides* is the main bovine pathogen in this group. Many species of the *Mycoplasma*

inhabits the bovine genital tract. Of these, *Mycoplasma bovis* is considered the most pathogenic. Adegboye (1979) did extensive work on bovine mycoplasmosis in Nigeria. Heifers inseminated with contaminated frozen semen can become repeat breeders with chronic suppurative salpingitis and endometritis (Nielsen, 1987). Other *Mycoplasma* of importance include *Ureaplasma diversus* with a frequency in the preputial cavity, and semen of bulls at artificial insemination units (Martel, 1991).

Viral Diseases Transmitted Through Artificial Insemination

Foot-and-Mouth Disease (FMD) - FMD is easily transmitted in semen (Cottral et al., 1968), and presents a serious risk for transmission by artificial insemination. Virus excretion can occur several days before clinical signs (Sellers et al., 1968). Semen quality usually deteriorates during the peak of the fever (Cottral et al., 1968). Convalescent cattle frequently retain virus in the pharynx for many months, which might be a ready source of infection to other stock. Equally significant is the donor bull with waning immunity, where exposure to the homologous or heterologous type of field virus may lead to superficial lesions and a period of seminal shedding of virus. Furthermore, even when fully protected, bulls exposed to a fresh source of field virus for sometime shed virus, not only from the pharyngeal region but also from the skin of the prepuce leading to seminal contamination.

Rinderpest - This was documented to be excreted in semen during acute disease, but there are no records of carrier state yet (Eze, 1977; Sellers, 1983; Wrathall, 1987).

Bluetongue - It occurs in a broad band around the world between 40° North and 35° South, showing the dissemination of the vector. Cattle are not the primary hosts for bluetongue, but transmission by *Culicoides* midges leads to a prolonged viraemia of up to three months. During this time most cattle are asymptomatic, but virus may be present in semen of bulls

during the viraemic phase (Bowen et al., 1985). The presence of virus in semen is not a regular occurrence and is probably due to blood cells carrying virus leaking into the genital tract via damaged capillaries (Bowen et al., 1985).

Lumpy skin disease - The virus has been isolated from semen for up to 20 days post-infection, but it has also been isolated from the semen of bulls with subclinical infection (Woods, 1988). Such infection is not easy to detect serologically and a history of herd and country freedom is usually needed. However, as it is deemed to be majorly vector transmitted, there is no published evidence for the venereal route.

Infectious Bovine Rhinotracheitis (IBR) - Bovine herpes virus type 1 (BHV-1) is the most common herpes virus to be found in the bull semen (Afshar and Eaglesome, 1990). The presence of virus in semen may lead to clinical signs in inseminated cows or heifers. Most likely it may lead to short returns to service in non-immune females, seroconversion and the retention of the virus for life (Parsonson and Snowdon, 1975). Two published approaches in connection with the removal of viruses from semen are: Bielanski et al., (1988) treated frozen thawed bovine semen experimentally infected with BHV-1 with 0.3 per cent trypsin solution. Virus was not isolated from any trypsin treated samples. Semen was successfully used to inseminate heifers after superovulation, but no major fertility studies on trypsin treated semen have been published. The second approach is that of Schultz et al., (1988) using immuno-extension. This is the principle whereby hyper-immune serum against the virus in question is added to the extender. It was demonstrated that infectivity could be eliminated without affecting fertility.

Bovine Virus Diarrhoea (BVD) - This virus has been demonstrated in semen (Brownlie, 1991; Paton et al., 1989). Meyling and Jensen (1988) have reported the infection of heifers after insemination with semen taken from acutely infected sires. Virakul et al., (1988)

Artificial insemination and disease transmission in Nigeria.

recorded early embryonic death and repeat breeding after exposure to infection, it affected rate of conception and also resulted in deterioration in semen quality.

In BVD, IBR and Bluetongue, clinical signs are rarely evident but the detection of virus in semen is of great importance.

Conclusions

The review showed that extreme caution must be taken to ensure that artificial insemination practice does not spread genetic defects or pathogens. With the ability of bulls to give up to 1000 doses from one ejaculate, and the widespread distribution of artificial insemination at local government, state, national and international levels, the degree for the spread of disease is considerable.

The results obtained by different investigators clearly showed that addition of antibiotics to semen cannot be seen as a substitute for the careful, sanitary collection of semen with a low bacterial content from healthy disease-free males. In addition, frozen semen could serve as a means of transporting diseases from one country to another. The freezing of semen enables many infectious agents to survive and cryoprotectants may render antibiotics less effective (Bartlett, 1981). Given the above reasons and other human error related to semen collection and processing it is of utmost importance that all male animals or birds intended for artificial insemination be free of brucellosis, tuberculosis, trichomoniasis, leptospirosis, campylobacteriosis, IBR-IPV, foot-and-mouth disease and other viral and mycotic infections.

The Office International Des Epizooties (OIE) (1986) in Europe; National Association of Animal Breeders (NAAB, 1989) in USA and the European Economic Community Directive (EEC, 1988) have defined guidelines and standards for practical artificial insemination in domestic animals. This strictly speaking is not the case in this country where artificial insemination is practised without due respect to

disease transmission. With a constantly changing spectrum of disease there must be no room for such complacency (Anon, 1992).

As a priority, producing pathogen-free semen in an enclosed stud of sires with a regular health-testing programme under official supervision is a must not negotiable. The testing programme should take into consideration the national animal health status as well as the source of the donors. A good knowledge of the natural history of the disease will determine the timing of the tests in relation to semen production (Sellers, 1983; Hare, 1985). It should be noted that diagnostic tests have limitations as to sensitivity and specificity and there is latency to contend with (Guérin, 1989). New diagnostic techniques will lead to greater precision and confidence (Howard, 1986; FAO, 1981; Wrathall, 1987). Therefore, a battery of sound diagnostic tests are necessary to confirm virus, bacterial, fungal, and protozoan-free fresh or frozen semen potentially reserved for insemination at state, national and international trade. Also, culicoides control must be included in artificial insemination programmes.

Livestock artificial insemination practice must therefore be a joint campaign by the government, veterinarians, animal scientists, pasture agronomists, microbiologists and animal owners for whom artificial insemination is usually a worthwhile new experience.

References

- Adegbeye, D.S. and Kumi-Diaka, J. 1979. Isolation of *Mycoplasma bovis* genitalium from bovine genital tract and semen in Nigeria. *Nigerian Veterinary Journal*. 8: 24-26.
- Afshar, A and Eaglesome, M. D. 1990. Viruses associated with bovine serum. *Veterinary Bulletin*. 60: 93-109.
- Akinboade, O. A. 1980. Incidence of bovine trichomoniasis in Nigeria. *Rev. Elev. Med. Vet. Pays. Trop.* 33: 381-384.

- Annual Report of the Federal Department of Veterinary Research, Nigeria.** 1952 - 1955, p. 8.
- Annual Report of the Federal Department of Veterinary Research, Nigeria.** 1954 - 1955, p. 15-16.
- Anon** 1992. International disease surveillance. *Veterinary Record*, 130: 151-152.
- Azubuike, M. E. and Orji, B. I.** 1983. Palmwine as diluent for porcine semen. Abstract, *Nigerian Society for the Study of Reproduction*. 3rd Annual Meeting, March 13 - 16th, 1983, University of Ife, Ile-Ife.
- Bale, O. O. J.** 1980. Cultural and serological study of ovine and caprine brucellosis in northern Nigeria. *M. Sc Thesis*, Ahmadu Bello University, Zaria, Nigeria. 120 pp.
- Bale, O. O. J. and Kumi-Diaka, J.** 1981. Serological and bacteriological study of bovine brucellosis from Livestock Investigation and Breeding Centres in Nigeria. *British Veterinary Journal*. 137: 256-261.
- Bale, O. O. J.** 1984. Microbial ecology and immunology of the female genital tract of small animals. *Ph.D. Thesis*, University of Dundee, Scotland.
- Bartlett, D. E.** 1981. Bull semen: "specific micro-organisms" in disease control in semen and embryos. *FAO Animal Health and Production*. 23: 29-48.
- Bawa, E. K., Voh, A. A., Oyedipe, E. O., Adekeye, J. O., Dauda, P. M. and Rekwot, P. I.** 1987. Campylobacteriosis and bovine infertility and abortion in an artificial insemination in Nigeria. *Veterinary Record*. 120: 183.
- Bielanski, A., Loewen, K.G. and Hare, W. C. D.** 1988. Inactivation of bovine herpes virus-1 (BHV-1) from *in vitro* infected bovine semen. *Theriogenology*. 30, 649-657.
- Bowen, R. A., Howard, T. H. and Pickett, B. W.** 1985. Seminal shedding of bluetongue virus in experimentally infected bulls. In: *Bluetongue and Related Orbiviruses*, eds. T. L. Barber, M. M., Joachim and B. I. Osburn. pp. 91 -96. New York; Alan Liss.
- Brownlie, J.** 1991. The pathways for bovine virus diarrhoea virus biotypes in the pathogenesis of disease. *Archives of Virology*. Supplement. 3: 79-96.
- Butswat, I. S.** 1989. Ram semen preservation at ambient temperatures by flow dialysis techniques. *M.Sc. Thesis*, Ahmadu Bello University, Zaria.
- Chauhan, F. S., Mgongo, F. O. K. and Kessy, B. M.** 1984. Recent advances in hormonal therapy of bovine reproductive disorders: A review. *Veterinary Bulletin*. 54: 991-1003.
- Cottral, G. E., Gailunas, P and Cox, B. F.** 1968. Foot-and-mouth disease virus in semen of bulls and its transmission by artificial insemination. *Archiv für die gesamte Virusforschung*. 23: 362-377.
- Done, J. T., Torlocki, S., Richardson, C., Harkness, J. M., Sands, J. J., Patterson, D. S. P., Sweasey, D., Shaw, I. G. I., Winkler, C. E. and Duffell, S. J.** 1980. Bovine virus diarrhoea-mucosal virus: pathogenicity for the foetal calf following maternal infection. *Veterinary Record*. 106: 473-479.

Artificial insemination and disease transmission in Nigeria

- EEC.** 1988. Council Directive 88/407 - Health requirements applicable to intra community trade in and importation of deep frozen bovine semen (updated 1992).
- Ellis, W. A., O'Brien, J. J. and Cassells, J.** 1981. Role of cattle in the maintenance of *Leptospira interrogans* serova hardjo infection in Northern Ireland. *Veterinary Record*. 108: 555-557.
- Ellis, W. A., Cassells, J. A. and Doyle, J.** 1986. Genital leptospirosis in bulls. *Veterinary Record*. 118: 333.
- Eze, E. N.** 1977. *Viral infections in cattle in Nigeria. Beef production and quality control.* The First Continuing Education Course for Veterinarians Held at the Faculty of Veterinary Medicine, A.B.U., Zaria, Nigeria. July 25 - 29, 1977. Edited by Akerejola, O. O. pg. 164 - 171.
- Eze, E. N.** 1978. Isolation of brucellae from the Nigerian livestock and typing of such isolates. *Bulletin of Animal Health and Production in Africa*. 26(1): 29-36.
- Ezeh, A. O., Ellis, W. A., Kmety, E., Adesiyun, A. A. and Addo, P. B.** 1989. Bacteriological examination of bovine kidneys for leptospire in Plateau State, Nigeria. *Review of Science and Technical Office International Epizootics*. 9(4): 1005-1008.
- FAO.** 1981. Disease control in semen and embryos. FAO Rome. *Animal Production and Health*. 23.
- Guérin, B.** 1989. IBR/IPV. Effects on reproduction and control in AI stud. *Proceedings of the 1st Meeting of AI Vets in EEC*. Luxembourg.
- Hansel, W. and Alila, H. W.** 1984. Causes of postpartum anoestrus in cattle in the tropics. In: *Nuclear Techniques and Nutritional Disorders*. Proceedings of the Consultative Meeting 13 - 16 June, 1983, Vienna International Atomic Energy Agency, Vienna, 1984, pg. 21-40.
- Hare, W. C. D.** 1985. Diseases transmissible by semen and embryo transfer techniques. *Technical Series 4, Office International des Epizooties*, Paris.
- Howard, T. H.** 1986. CSS sire health: Present and future. *National Association of Artificial Breeders 11th Technical Conference*, Columbia.
- Kahrs, R. F.** 1981. Bovine viral diarrhoea (Eds. M. Ristic and McIntyre. Diseases of cattle in the tropics). *Martinus Nijhoff Publishers*, Hague, 189-195.
- Martel, D.** 1991. Proceedings of the 3rd Meeting of AI Vets in EEC, Albi, 1991.
- Meyling, A. and Jensen, A. M.** 1988. Transmission of bovine virus diarrhoea virus (BVDV) by artificial insemination with semen from a persistently-infected bull. *Veterinary Microbiology*. 17: 97-105.
- Ahmed, M. S.** 1989. Comparative evaluation of cryoprotective compounds for deep freezing of ram spermatozoa in tris diluent. *Ph.D Thesis*, Ahmadu Bello University, Zaria, Nigeria.
- NAAB.** 1989. CSS minimum requirements for health of bulls producing semen for artificial insemination. *National Association of Artificial Breeders*. Columbia, USA.
- Nielsen, K. H., Stewart, R. B. Garcia, M. M. and Eaglesome, M. D.** 1987. Enzyme immuno-assay for detection of *Mycoplasma bovis* antigens in bull semen and preputial washings. *Veterinary Records*. 120: 596-598.
- OIE.** 1986. International zoo sanitary code: *Zoo sanitary rules recommended by the OIE for international trade in animal and animal products*. 5th ed. updated 1988, Paris.

- Okoh, A. E. J.** 1980. An investigation of abortion in sheep in Rano L.H.C. near Kano, Nigeria. *Bulletin of Animal Health and Production in Africa*. 28: 135-136.
- Onipe, A. Y.** 1989. Formaldehyde preservation of ram spermatozoa. *M.Sc. Thesis*, Ahmadu Bello University, Zaria.
- Osinowo, O. A.** 1980. A practical AI scheme for Nigeria. *NAPRI Seminar Series*. 2: 1-15.
- Osinowo, O. A., Bale, J. O., Eduvie, L. O. and Oyedipe, E. O.** 1980. Characteristics of ram semen and development of new techniques. *Annual Report of Research in Animal Production*. 23.
- Paton, D. J., Goodey, R., Brockman, S. and Wood, L.** 1989. Evaluation of the quality and virological status of semen from bulls acutely infected with BVDV. *Veterinary Record*. 124: 63-64.
- Parsonson, I. M. and Snowson, W. A.** 1975. The effect of natural and artificial breeding using bulls infected with or semen contaminated with IBR virus. *Australian Veterinary Journal*. 51: 365-369.
- Perry, E.J.** 1968. Artificial insemination of farm animals. 4th edition Rutgers University Press, New Brunswick, New Jersey.
- Raamy, B.** 1966. An enzootic of bovine TB transmitted by AI. *Record of Veterinary Medicine*. 142: 729.
- Rekwot, P. I., Voh, A. A. Jrn., Oyedipe, E. O., Opaluwa, G. I., Sekoni, V. O. and Dauda, P. M.** 1987. Influence of season on characteristic of the ejaculate from bulls in an artificial insemination centre in Nigeria. *Animal Reproduction Science*. 41: 187-194.
- Schultz, R. D., Kaproth, M. and Bean, B.** 1988. Immuno-extension: A method to eliminate viral infectivity in contaminated semen. *11th International Conference on Animal Reproduction and AI*, Dublin. Paper No. 522.
- Sellers, R. F.** 1983. Transmission of viruses by artificial breeding techniques: a review. *Journal of the Royal Society of Medicine*. 76: 772-775.
- Sellers, R. F., Burrow, R., Mann, J. A. and Dawe, P.** 1968. Recovery of virus from bulls affected with foot-and-mouth disease. *Veterinary Record*. 83: 303.
- Sekoni, V. O., Kumi-Diaka, J., Saror, D. I. and Njoku, C.** 1988. The effect of *T. vivax* and *T. congolense* infections on the reaction time and semen characteristics in the zebu bull. *British Veterinary Journal*. 144: 388-394.
- Vandeplassche, M.** 1982. Reproductive efficiency in cattle. A guideline for projects in developing countries. *FAO No. 255*, 118 pp.
- Virakul, P., Fahning, M. L., Joo, H. S. and Zemjanis, R.** 1988. Fertility of cows challenged with a cytopathic strain of BVD during outbreak of spontaneous infection with non-cytopathogenic strain. *Theriogenology*. 29: 441-449.
- Voh, A. A. Jrn., Buvanendran, V. and Oyedipe, E. O.** 1987. Artificial insemination of indigenous Nigeria zebu cattle following synchronization of oestrus with prostaglandin F₂alpha. I. Preliminary Fertility Trial. *British Veterinary Journal*. 143: 136.
- Voh, A. A. Jrn.** 1990. A decade of practical artificial insemination extension services at the National Animal Production Research Institute, Shika (1979 - 1989). In: *Application of Animal Reproduction and Artificial Insemination Techniques to Livestock Production in Nigeria*. pp. 260-272.
- Woods, J. A.** 1988. Lumpy skin disease - A review. *Tropical Animal Health and Production*. 20: 11-17.
- Wrathall, A. E.** 1987. Disease transmission by semen and embryo transfer techniques and implications for international trade. *State Veterinary Journal*. 41: 19-30.

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