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Pedigree charting and inbreeding estimation in N'Dama cattle herd at Fashola stock farm

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Target audience: *Ranch Managers, Livestock Experts, Software Developers and Research Scientists*

Abstract

The insufficient and mostly inconsistent record keeping practices usually on Livestock farms in Nigeria and the need for the animal breeder to know the pedigree of individual animals in order to determine their level of inbreeding and relationship has been a challenging task. A computer-based pedigree charting and inbreeding coefficient computation software was developed with Nantucket Clipper ® 5.01 and Nantucket Tools II ® for Clipper 5.01 to take care of animals with minimal parental information as usually recorded in most Nigerian farms. The program finds, charts and saves the pedigree information up to the seventh generation on all calves with born on the farm with both parental information. The new database file is then used to calculate the inbreeding coefficient of that individual animal using Wright's formula. The speed and capacity of the computer program is basically determined by available computer resources. Records of 4184 N'Dama calves born between 1947 and 1984 at Fashola Stock Farm, Oyo State, Nigeria was used to test the efficiency and efficacy of the computer program. Only 273 of 4184 calves (6.53%) were inbred with an average inbreeding coefficient of 9.71%, while five out of 293 sires (1.71%) with inbreeding coefficient of 9.25% and 43 out of 1849 dams (2.33%) with inbreeding coefficient of 9.95% were inbred. The inbreeding coefficient for the entire population was 0.63%; for males the mean was 0.70% and 0.58% for females. The study shows that although inbreeding was low in the N'Dama population at Fashola Stock Farm as the number of inbred animals in the population is relatively low, however the inbreeding level of these animals is high, which may be as a result of non-compliance with consistent breeding policy on the farm, and lack of proper, consistent and adequate registration system on the farm which all may be responsible for the inbreeding observed in the N'Dama population at farm.

Key words: *N'Dama, Cattle, Software Development, Pedigree Charting and Inbreeding Coefficient Estimation*

Description of Problem

Inbreeding, the mating together of individuals that are related to each other by ancestry, entails the mating of animals that are more closely related than the average of the population from which they come [1]. Usually, the aim of deliberate inbreeding is not to study the effects of the breeding method per se, but rather to try to produce superior inbred stock by ensuring the concentration of the genes of interest within the herd [1].

The Fashola Stock Farm was established to study of N'Dama breed, essentially set up as a breeding and improvement centre in 1947. Consequently, the records available can give an insight into the various environmental and genetic factors involved in the present level of productivity, albeit scanty and incomplete. While several breeding methods had been adopted on the farm at various times in the past, it is not unexpected that along the line there would have been mating of animals with common ancestry.

The available calving records are sufficient to provide information on the extent of relationship within the herd. However, since information contained in calving records on the farm does not extend beyond the immediate parents of a calf, and the need for the animal breeder to know the pedigree of individual animal, to determine relationship amongst them and estimate their inbreeding coefficients has been a challenging task. Usually, insufficient information on the remote parents of animals are seldom available in the animal population spread over many years are available at Nigerian farms. Fashola Stock Farm established in 1947 is one of such farms where data on N'Dama cattle has accumulated. The non-importation of fresh genetic stock for a relatively long time on the farm, can be expected to lead to some inbreeding since there is inconsistent management systems adopted on the farm.

The aim of deliberate inbreeding is not to study the effects of the breeding method per se, but to produce superior inbred stock by ensuring the concentration of genes of interest within a herd [1]. This breeding method has been extensively used in obtaining high producing animals and maintaining elite stocks [2]. Various researches on inbreeding indicated that inbreeding has not always had the same effect on productivity, but in most instances, productivity has declined with increasing levels of inbreeding [3].

In order to circumvent the undesirable effects of inbreeding, some suggestions have been proffered to avoid inbreeding and improve livestock productivity. It was suggested that in a situation where animal populations are small, there should be a rapid turnover of sires to minimize inbreeding [4]. Crossing of full-sib should be avoided and modified full-sib selection could be used alternately with half-sib selection or typical full-sib selection may be carried out once after several cycles of modified full-sib selection [5].

The major consequence of inbreeding is increase in the probability that two alleles at a particular locus in an individual are identical by descent, which consequently result in an increase in the proportion of homozygous loci in the inbred individual.

The undesirable consequence of this increased homozygosity is a decline in performance in traits associated with general vigour such as reproduction, survival and growth rates [6; 7; 8; 9]. Inbreeding increases uniformity for simply inherited and highly heritable traits but it also leads to increased variability for economically important quantitative traits [10].

Despite the decreased performance associated with inbreeding, efforts are still being made to deliberately mate animals that are closely related as a method in animal breeding. This is based on the fact that when an inbred line is formed from an elite stock, it can contain no genes however inferior it may appear which were not present in its admired progenitors, nor can it hand any others on to its descendants [11].

There had been several attempts at estimating inbreeding coefficients with computer software in different herds in the past [12; 13; 14; 15; 16; 17; 18; 19]. However, all the previous approaches are well suited to the standard pedigree records kept on all animals in the developed countries who all had databases of all their animals.

Inbreeding coefficient, a measure of the degree of inbreeding, is the correlation between uniting gametes and was first established by Sewall Wright in his classical path coefficient analysis of inbreeding systems which provides an expression for the degree of homozygosity that occurs as a result of mating related animals, as the quantitative basis for estimating consequences from any sort of inbreeding based on pedigree relationships, ignoring possible effects of selection and assortative mating [20; 21]. Various attempts have been made to estimate inbreeding coefficient after this initial effort [22; 23; 24; 25; 26; 27].

Table 1: Annual rate of Inbreeding and sex distribution of calves at the Fashola Stock Farm (1947 – 1984)

Year of Calving		Calves			Inbreeding Coefficient (%)		
	N	Male	Female	Sires	Overall	Male	Female
1947	9	4	5	5	0.00	0.00	0.00
1948	59	28	31	15	0.00	0.00	0.00
1949	64	34	30	13	0.00	0.00	0.00
1950	56	28	28	9	0.00	0.00	0.00
1951	56	23	33	5	0.00	0.00	0.00
1952	56	30	26	9	0.00	0.00	0.00
1953	71	35	36	10	0.53	0.36	0.69
1954	105	54	51	12	0.48	0.93	0.00
1955	133	68	65	15	0.56	0.74	0.39
1956	145	77	68	16	1.47	1.62	1.29
1957	240	135	105	22	1.12	1.34	0.83
1958	233	118	115	20	1.17	1.38	2.17
1959	102	57	45	12	1.78	1.54	2.08
1960	175	83	92	14	1.46	1.73	1.22
1961	202	103	99	16	1.45	1.61	1.29
1962	176	95	81	17	0.59	0.49	0.69
1963	136	68	68	10	0.62	0.37	0.87
1964	186	93	93	11	0.12	0.13	0.10
1965	166	94	72	20	0.30	0.13	0.52
1966	80	27	53*	16	0.43	1.22	0.03
1967	105	1	104*	23	0.27	0.00	0.27
1968	82	3	79*	17	0.46	0.00	0.48
1969	3	1	2	3	0.00	0.00	0.00
1970	17	3	14*	11	0.74	0.00	0.89
1971	26	12	14	9	0.00	0.00	0.00
1972	91	12	79*	17	0.50	0.00	0.57
1973	76	21	55*	13	0.41	0.00	0.57
1974	157	76	81	19	0.12	0.21	0.04
1975	256	142	114	30	0.66	0.85	0.43
1976	171	82	89	27	0.07	0.10	0.05
1977	151	73	78	18	0.02	0.00	0.03
1978	157	77	80	54	0.72	0.85	0.59
1979	147	84	63	47	0.21	0.33	0.05
1980	120	63	57	43	0.47	0.30	0.66
1981	63	27	36	33	0.00	0.00	0.00
1982	66	24	42+	30	0.19	0.52	0.00
1983	37	19	18	15	0.00	0.00	0.00
1984	9	1	8+	8	0.00	0.00	0.00
1947 - 1984	4184	1975	2209*	293	0.63	0.70	0.58

*=P <0.01 +=P<0.05

Aside from the cost of acquiring such software, the irregular method of record keeping and inconsistencies in the animal recording system at Fashola Stock Farm and indeed other similar farms in Nigeria, makes the use of previously developed software impracticable. Faced by the fact that the farm had been closed to new importation for a very long time and the dwindling performance of the animals in most productivity traits on the farm which smacks of consequences of inbreeding depression, this study aims to develop a novel computer program that can handle the peculiarities of the records kept on the farm and make such software require minimal computer resources to encourage its deployment and future use.

To this end, the objectives of this study are to develop a computer program that can trace, retrieve all the pedigree information on all animals born on any farm whose immediate parents (sire and dam) are known and chart the pedigree of any animal up to the seventh generation and calculate the inbreeding coefficient of such animal using the path analysis method to deploy the software to handle inbreeding estimation for animal production and breeding productivity data.

Materials and Methods

This study involves the development of a new computer software named the Pedigree Chart Master Systems (PCMS) as previously described [29].

Computer Software Development

The program was written with a programming language Clipper ® and it requires a minimum of 512Kb of memory with at least a double density floppy disk drive and a hard disk capacity of at least 20Mb. It operates on DOS 3.3 and above and supports both VGA and Monochrome cards.

The software package consisted of some useful stand-alone modules for use in animal breeding research. These modules can be accessed through a user-friendly pop-up menu environment within the software that requires only highlighting of prompts and selection of desired routines. It requires minimal computer experience to use most of the programs available in the package, and it is intended for use exclusively for research and has been optimized for both speed and program size.

Installing and Accessing the Package: The package on installation access the main program displaying five (5) menus on the top row of the program. These menus are: File, Edit, Toggles, Utility and Help menus. These menus can be activated by either pressing the F10 function key (usually at the topmost row of the computer keyboard) and using the left or right arrow keys (<- or ->) to highlight the menu you may wish to open. Press the return key to select the highlighted menu. This open up the menu and you can then highlight and select whatever option you may wish to invoke on the menu.

Alternatively, you may activate the menu system by holding down the Alt key (usually at the bottom row of the keyboard) and simultaneously press the highlighted character of the menu i.e. Alt + F will open the file menu while Alt + T will open the Toggles menu.

An option preceded with an arrowhead indicates that such option opens to a sub-menu and is achieved by highlighting the option and pressing the return key. Movement and selection in the sub-menu is as described for the menu systems e.g. highlighting the Save As menu option and selecting it will open the sub-menu of Normal Text (TXT) and Dbase IV ® [28] Format (Dbf).

Data Preparation: Since there are inconsistencies in the identification system adopted on the farm, the program has option to standardize all calf identification such that it is unique. This option is specifically intended for the case study in which case the animal registration number is neither unique nor consistent. This program is developed to give the animals new identification number and changing all occurrences of such animals with old number with the new identification numbers. The option opens to a sub-menu and it comprises of the following three options viz: New Identification No., Convert Male Animals and Convert Female Animals.

The Algorithm is an iterative system based on the fact that the birth recorded on the Fashola Stock Farm for any particular month between 1947 and 1984 is not up to a hundred (100) and the registration method adopted for most part of the period is based on sex, e.g. we may have animal with registration number 310150 as a Bull and Heifer (i.e. two animals share the same number). Based on the fact that the identification number of the animals must be unique in order to have a reliable and accurate pedigree information, efforts are made to make the identification number unique. This is achieved by sorting the animals on their date of birth, the sorted database file is now modified to include three new fields for the new identification numbers (calves, sires and dams).

Calf Re-identification: This gives new identification number to all the calves born on the farm and available on the database. The new number given to the animals is a six digit number comprising, the first two digits being the year of birth, the next two digits being the month of birth and the last two digits being the number of the birth in that month irrespective of sex or breed. For example, the third animal born in June of 1957 is registered as 570603 where 57 is the year of birth, 06 the month and 03 the birth number of the animal. The identification starts with the first animal and ends on the last animal in the database.

Male animals born on the farm and used as sires on the farm were assigned new identification number. The search is for locating the first male animal born on the farm and locating where it was used as sire and changing the old sire number with the new one for all the occurrences of that particular animal as sire. All Sires in the database that were born on the farm or whose ancestry can be traced were given the new number.

Similarly, female animals born on the farm and later used as dams on the farm were also identified and appropriately tagged. The search is to locate the first female animal born on the farm and locating where it was used as dam and changing the old dam number with the new one for all the occurrences of that particular animal as dam. All dams in the database that were born on the farm or whose ancestry can be traced were given the new number.

Database Structure Modification: This module automatically modifies the database structure of the file whose pedigree we want to chart. It is done in preparation for the charting of the pedigree and calculation of inbreeding coefficients. It adds additional twenty-nine fields to store the pedigree information and inbreeding coefficient of the animals. Four of the fields are used to store identification No. of the grandparents, eight to store the great grandparents, sixteen to store the great great grandparents and the remaining one is to store the computed inbreeding coefficient.

Pedigree Charting: Selecting this will transform the data and pedigree information of animals except the base generation will be traced, retrieved and written to disk. The pedigree chart is based on the algorithm that every animal born on the farm and whose immediate parents are known can be used to draw the pedigree chart. A search on a sire that was born on the farm will give us the two parents of such sire which represents two of the grand-parents of the calf we started the search with. The other two grandparents are retrieved by tracing the parents of its dam. This search is iterative and continues to the fifth generation starting with the calf as the first generation.

The retrieved pedigree information is stored in the new fields. The pedigree information is permanently stored on the disk and each calf born on the farm has its associated pedigree chart. This pedigree information is what will be used via the path tracing method to calculate the inbreeding coefficient of the animals using the Wright's formula [21].

Inbreeding Coefficient Computation: This option calculates the individual inbreeding coefficient of all the animals born on the farm and listed in the records using the Wright's [21] path method as;

$$F_x = \sum \left(\frac{1}{2}\right)^{n+n'+1} (1 + F_a)$$

where F_x = the inbreeding coefficient of individual x

n = the number of generations through the sire

n' = the number of generations through the dam

F_a= the inbreeding coefficient of a common ancestor a

The F_x is the sum total of all possible paths of the ancestors common to both the sire and dam. And this can be computed with the knowledge of the pedigree of the individual **X**. This inbreeding coefficient of an individual is one half the numerator of the relationship coefficient between its sire and dam.

The algorithm of the software is to pick an animal through the sire (included) and search for recurrence of such animal on the dam side of the chart. The sum of all such occurrences gives the inbreeding coefficient of the calf. Some useful conditional statements are built into the program to prevent over estimating or under estimating the inbreeding coefficient. For example, the inclusion of the inbreeding coefficient of an inbred ancestor (F_a) in the calculation of the F_x (Inbreeding coefficient of calf) involving such ancestor.

The software is sequentially operated as it starts with calculation from the first generation to the seventh. It is pretty fast and very accurate, and the calculated values are stored in the field meant for inbreeding coefficient, which can be retrieved afterwards without going through the process all over again.

Charting: This option allows you to display the pedigree chart via two options on the sub-menu i.e. Record Number and Identification No. The requested information is displayed as in Figure 1.

Pedigree Chart by Animal Number: This sub-menu prompts you for the record number you want to start the display from and the record number you wish to stop. All the selected records will be displayed, showing their pedigree chart and inbreeding coefficient. Pressing any key but F10 will move to the next record to display while the F10 key will abort the procedure. The program runs until an F10 key is pressed or the upper limit record is reached.

Alternatively, a specific animal number can be specified and the pedigree and inbreeding coefficient of that particular animals are immediately searched for and if found, displayed on the monitor as in Figure 2. You have an option of searching for another animal or quitting the program. However, if the requested animal is not available in the database file, you will be so informed and you may re-enter another animal or quit.

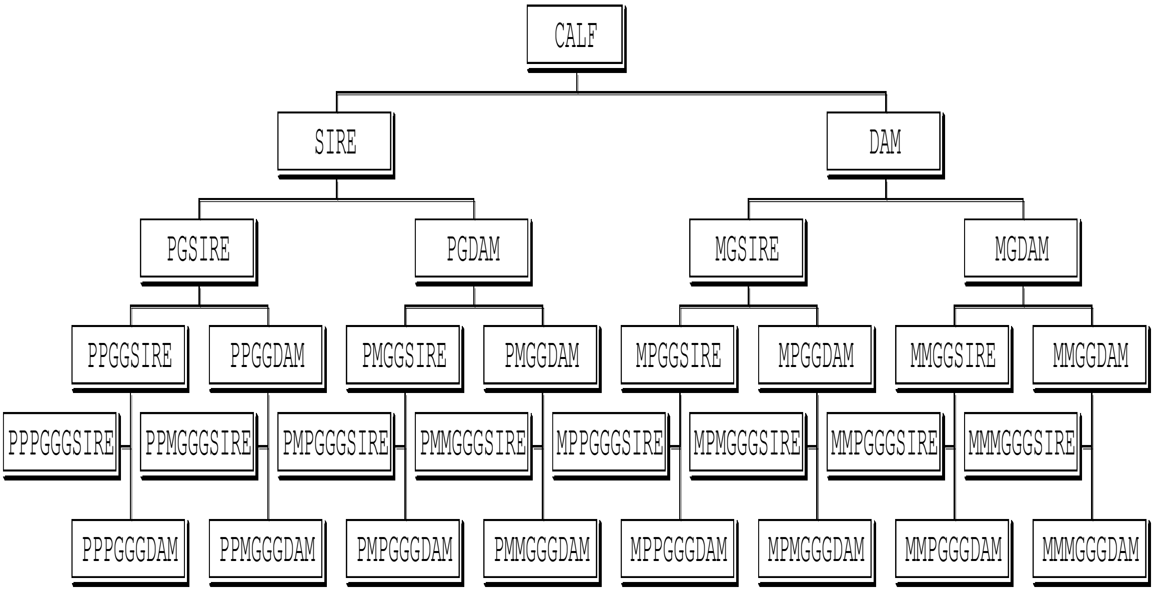

Figure 1: Schematic diagram of a pedigree chart

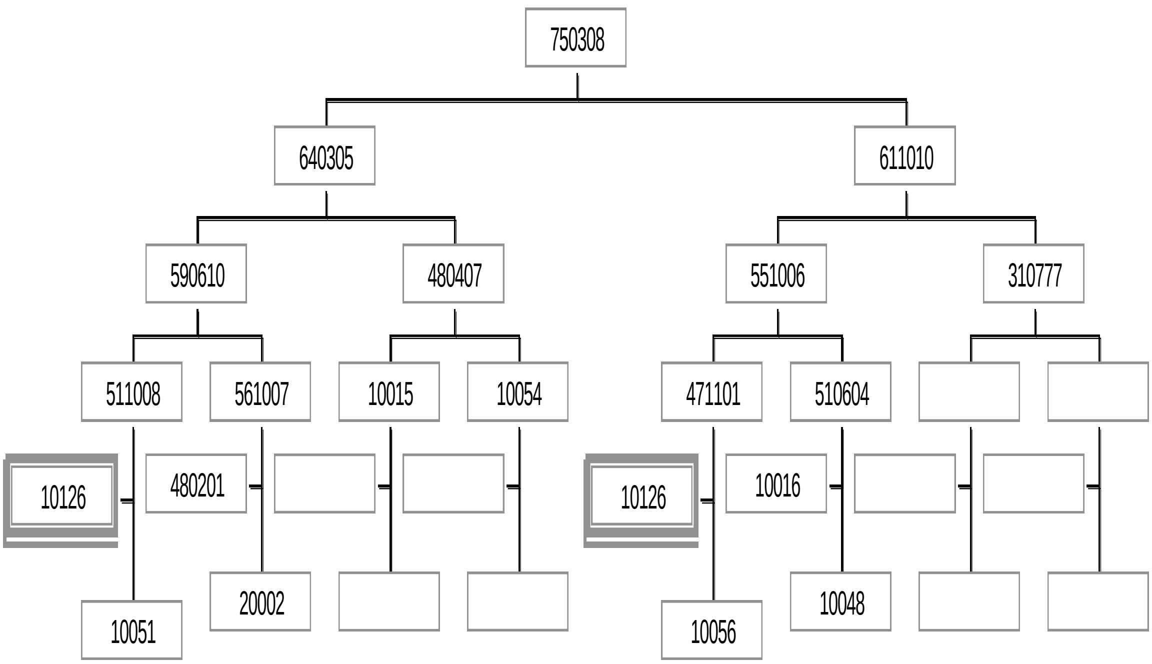

Figure 2: Pedigree chart of calf # 750308 showing its common ancestor (10126)

Data Preparation and Statistical Analysis

Exploratory data analyses and charts generation were done using Microsoft Excel ®. A test of goodness of fit for observed counts of male and female was by Chi Squared from the values obtained from [28].

The Chi Squared is given as;

$$X^2 = \sum \frac{(o-e)^2}{e}$$

where X^2 = Chi value

o = the observed count

e = the expected count

Results and Discussion

Pedigree Charting

Apart from the pedigree chart obtainable from the Pedigree Chart Master Systems (PCMS) (29), basic statistics of population were also obtained in a sub-routine of the program. Table 1 describes lists the frequency distribution of all calves by year of birth and average annual rate of inbreeding.

Calving Distribution: The number of calves dropped between 1947 and 1953 was relatively stable before the introduction of some heifers from Ilora Farm in 1953. There was a consistent increase in the number of calves dropped on the farm from 1954 to 1958. There was a sharp drop in number of calves born in 1959 and this may be attributed to the gradual withdrawal of the colonial administrators of the farm prior to independence. The number of calves dropped between 1960 and 1965 was relatively stable and this may be due to commencement of proper documentation of calving on the farm.

However, the inconsistent distribution observed between 1966 and 1973 may be attributed to several factors, which include the political crisis within the Western region in 1966 up to the civil war era of 1967 to 1970 and the post war period of 1970 to 1973. Another factor that may be responsible for this inconsistent pattern of distribution may be explained by the fact that this project only takes into consideration the Purebred N'Dama population and all those Crossbred calves produced between 1964 and 1968 were not included in these analyses.

The calving distribution increases from 1974 to 1975 when it sharply declines in 1976 up to 1984. This marked decline in number of calves dropped in 1976 was as a result of the fractionalization of the herd due to asset sharing among the three new states created from the old Western region in 1975. Also, the return to civil rule in 1979 with its associated fiscal and managerial indiscipline may be adduced for the lower calves produced in the early 1980's [29].

For ease of comparison of the calving distribution, the years can be grouped into various management period to give a clearer picture of how these periods affect the number of calves dropped. This difference can only be attributed to political rather than natural causes (Figure 3).

It was observed from Figure 3 that incessant state creation by the various Military regimes that ever ruled the country led to the fractionalization of the herd. Assets were shared politically and animals removed to the new states. This perhaps led to the fluctuations both in the herd structure and in the level of inbreeding. Record keeping systems are often disrupted by the incessant changes in management even at the best of times on the farm. The most stable periods for consistent and reliable record keeping systems were between 1947 and 1960 and from 1963 till 1966. The first period coincided with the presence of the Colonial administrators in Nigeria prior to independence. The second stable period was the duration when the USAID Livestock Advisor was present and involved in the management of the Fashola herd. Other periods are littered with one type of political instability of the other.

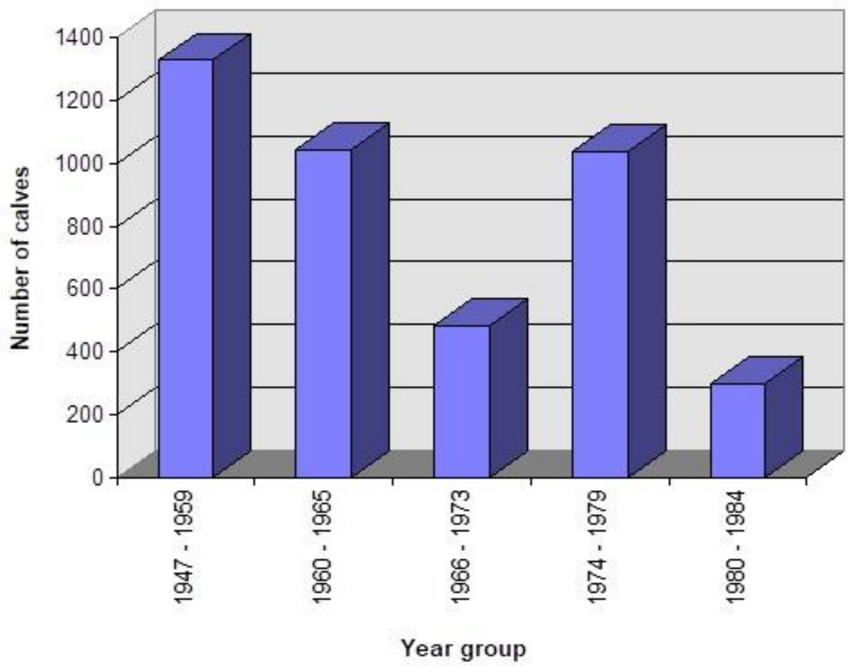

Figure 3: Calving distribution of N'Dama by year group at Fashola Stock Farm (1947 – 1984)

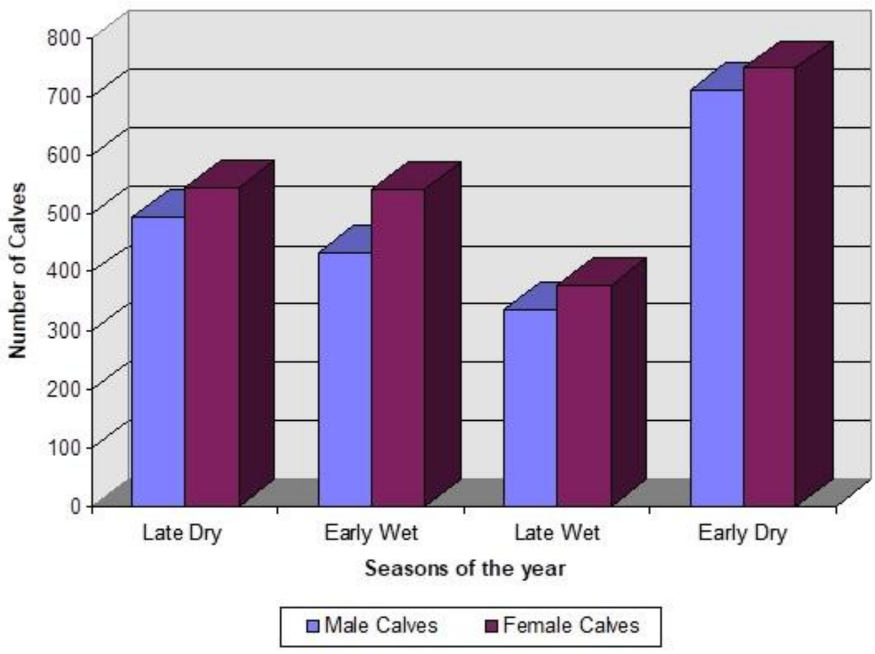

Figure 4: Frequency distribution of calving by season of birth and sex of calf at Fashola Stock Farm (1947 – 1984)

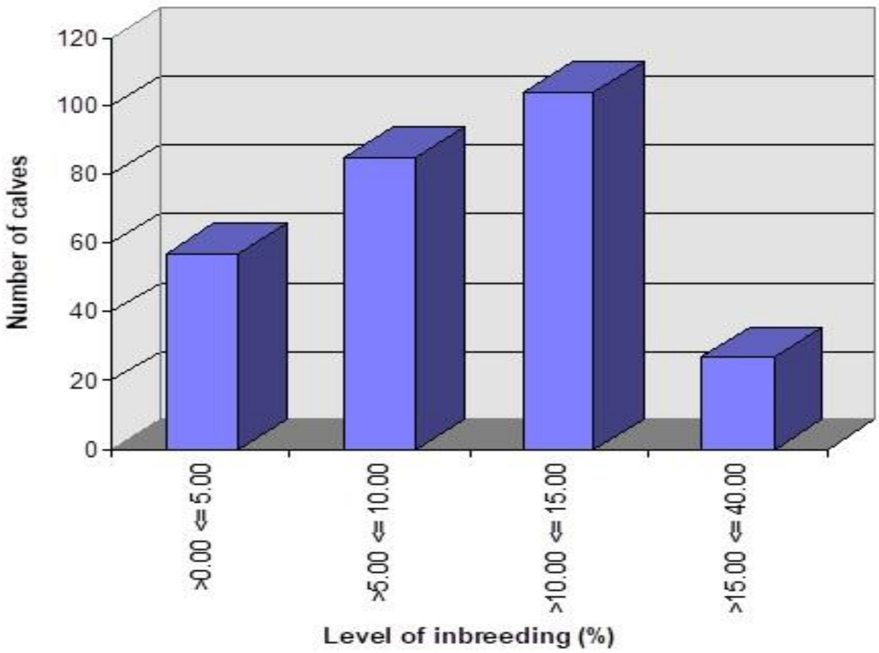

Figure 5: Frequency distribution of inbred calves by level of inbreeding at Fashola Stock Farm (1947 – 1984)

Based on this classification, the lowest calf crop was recorded in the late wet season (17.10 percent of the total calf population) while the largest calf crop was in the early dry season (34.80 percent of total calf crop). Thus, close to 60 percent of the total calf crop were dropped in the dry season (October - March). It is pertinent to note that gestation length in cattle is averagely 280 days and that animals that conceive during the early and late wet season will calve during the early and late dry seasons respectively. This implies that calves born in the dry seasons were actually conceived in the wet seasons and this period coincides with the period of fresh lush pastures for the first two trimesters of the pregnant animal and this is the period of high conception rates. This observation is in line with earlier reports that explained that conception rates was highest at the beginning of the rains in April and lowest in July [30], which was also corroborated in another report [31] that more calves are dropped in the dry seasons than the wet seasons. The scarcity of pastures and degradation of the biomass through bush burning, and the lignification of the few available pastures during the dry season may be responsible for the low conception rates during this period.

Sex Ratio: The probability of having a male or female calf in any cattle (beef or dairy) enterprise is 50 percent. Table 1 describes the frequency distribution of calves by sex and year of birth.

Out of the 4184 N'Dama calves recorded on the Fashola Stock Farm between 1947 and 1984, only 1975 were male calves and 2209 were female calves. This 47:53 ratio significantly ($P<0.01$) deviated from the 50:50 ratio expected on the farm (X^2=13.09, 1df). However, of the 38 years covered in this study only the sex ratio of six years (1966, 1967, 1968, 1970, 1972 and 1973) were significantly ($P<0.01$) different from the expected ratio and two years (1982 and 1984) significantly ($P<0.05$) deviated from the expected 50:50 sex ratio.

It is observed that these two periods coincided with the period of the civil strife and the civilian rule in Nigeria. These two periods are the duration of worst management practices on the farm and most of the calving in that period may not have been properly documented. This lack of information on male calves for these years was so high that it affected the sex ratio of the entire population.

Inbreeding Level: The results obtained from the module of the program that calculate inbreeding coefficient of calves born on the Fashola Stock Farm revealed that inbreeding took place on the farm between 1953 and 1984.

Out of 4184 N'Dama calves born within these periods, only 273 (6.53 percent) were inbred to varying degrees as outlined in Figure 5.

Only five out of 293 sires (1.71 percent) used on the farm were inbred and only 43 of the 1849 dams (2.33 percent) were inbred. The least inbred calf had an inbreeding coefficient of 0.781 percent while the most inbred had 37.50 percent inbreeding coefficient. The least inbred sire used for breeding on the farm was 3.125 percent inbred and the most inbred sire was 25.00 percent inbred. The least inbred dam was 1.563 percent inbred while the most inbred dam was 25.00 percent inbred.

The mean inbreeding coefficient for the entire calf population was 0.63 percent, while the mean inbreeding coefficient for the male calves was 0.70 percent and for the females it was 0.58 percent. Inbreeding started on the farm in 1953 and for 28 years of the 38 years covered in this study. Inbreeding coefficient of calves born in 1953 was 0.53 percent but with the introduction of new animals from Ilora that year, the inbreeding coefficient dropped to 0.48 percent in 1954. However, there was a consistent build-up in the inbreeding coefficient of the calves from 1954 up to 1959. It thereafter steadily decreases to 1963 after which it did not follow any consistent pattern. The least inbreeding coefficient was recorded in 1977 (0.02 percent) while the highest inbreeding coefficient was recorded in 1959 (1.78 percent).

With the introduction of 93 (20 bulls and 73 in-calf heifers) head of cattle to the Fashola Stock Farm in 1947, breeding practices were normal. The initial head of cattle introduced to the farm was regarded as the base generation and are assumed not to be related by descent or ancestry for the purpose of this study. This assumption is backed-up by historical events of the importation from Guinea. Other later importations were from Sierra Leone, Belgian Congo (Zaire) and lately The Gambia.

The pattern of inbreeding observed in this study can best be explained in the context of the inconsistent management history of the farm. The period when the herd was relatively few and closed to new importation recorded higher levels of inbreeding, new importation to the farm diluted the genes and thus inbreeding declined. The history of initial and subsequent importation is as previously described [30; 32]. Usually the pedigree information of the newly imported animals was not available and the animals were assumed not to be related to the ones already on the farm. This assumption appears reasonable since importation were from different countries.

Another major factor that may be responsible for this irregular pattern of inbreeding levels can be adduced to the political disturbances occasioned by independence from colonial rule, civil war and creation of states. There was no deliberate adoption of inbreeding as a breeding policy on the farm. Every time there was a state of political instability in the country, there was no consistent and conscientious record keeping system.

The period of civil war (1967 - 1970) in this country also ushered in yet another period when record - keeping system was at its worst on the farm. This is because calving was not properly documented and when recorded, little or no information was available on the parentage. The reason why it was difficult to obtain this information was perhaps due to the unsettled political climate and the intermittent war and rumours of war.

Also, the inconsistent method of registration of animals due to changes in management staff make it impossible to trace the pedigree of many calves. In fact, the computer program developed was specifically initiated to address this anomaly but it must be admitted that some animals which were removed from the records when they failed the tests of authenticity may underestimate the inbreeding coefficient of N'Dama cattle on this farm. That is the reason why these analyses were limited to only those animals whose genealogy could be traced by the computer.

The non-availability of information on male calves during the civil war era also made the tracing of pedigrees thereafter more difficult, that was why the level of inbreeding and the number of inbred calves born immediately after that period was very low relative to those years preceding the civil war. The breeding policy of the farm was not strictly adhered to as dictated in the mandate setting up the farm. Lack of proper records for all activities on the farm and the inadequate information contained in the few record books give room for some doubt about the efficiency of the management.

Due to the fact that the fundamental objectives of this study were to develop a computer program to chart pedigree and calculate inbreeding coefficient of individual animal born on the farm, recommendations made will only address the specific problems encountered in the course of this study.

Since the availability of accurate and reliable data on the performances of an animal is essential to the overall appraisal of the genetic worth of that individual animal, it is therefore necessary that adequate provision be made at the Fashola Stock Farm for the recording of the animal's individual performance. There should be a data bank to contain information on all animals that ever existed on the farm. Information on the pedigrees and progenies of all breedable animals should be available.

At the national level, there should be a central animal registry whereby census of all classes of livestock in the country shall be kept. There should be a unique registration system where each individual animal is given a unique identification number.

Every transaction concerning such animals should be well documented with reference to the identification of the animal. Information on the animal e.g. sex, breed, date of birth, identification number of pedigree or progenies (if available), health records and several other productivity indices that may be computed on that individual animal should be maintained in a database. This will assist in the retrieval of necessary information about an animal before such animal can be sold, bought or transferred for breeding on other farms.

Enforcement of this registration on every livestock farmer is the first step to assessing the genetic potential and productivity of animals in this region of the world. The central animal registry should work hand in hand with several other livestock and allied research stations (local and international) and ensure that information flow to and from these research organizations is with minimal inconvenience on the part of the researchers and the end users. There should be a standard (nationally acceptable) format for the recording of animal's productivity data so that comparisons across regions / breeds can easily be made.

Conclusions and Applications

The following conclusions are drawn from the study.

1. Inbreeding actually took place on the farm between the years 1953 and 1982. This occurred due to the management practice adopted on the farm with regard to breeding. This is because pasture mating was practiced in most part of the farm's history and proper documentation of breeding animals was lacking.
2. The number of inbred animals on the farm may actually be greater than detected and reported in this study. This is because most animals transferred or imported to the farm are not usually accompanied with the necessary pedigree information. Thus, such animals are considered as being non-inbred and not related to the animals already on the farm.
3. The registration system adopted for animal identification on the farm is very confusing and greatly misleading. The unavailability of proper records during the political crises periods coupled with the intermittent fragmentation of the herd as a result of incessant state creation may also be responsible for the low number of inbred animals observed in this study.
4. Records kept on the farm must be up to date and information therein must be as accurate and reliable as possible. Information obtained from the animal breeder should be used to assess the productivity of the animals.

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