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### INTERROGATING HETEROSIS AND CONSANGUINITY FOR LIVESTOCK AND HUMAN POPULATIONS

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#### ABSTRACT

Heterosis or hybrid vigour is an increase in the yield of a hybrid animal over those of its parents; and consanguinity, the quality of being descended from the same ancestor as another person; have been discussed independently by scholars. However, this study attempts a side by side investigation of heterosis and consanguinity as they affect livestock and human populations in antiquity and Nigeria, with a view to understanding how these cultures/strategies can positively or negatively affect the progress and prosperity of a society. The social development theory is adopted to further present an expansionary view on how society can grow and prosper with regard to these themes. The argument that heterosis or exogamy is more advantageous than consanguinity for the growth of a society is put forward in the discourse. Further studies may examine excessiveness in heterosis with regard to human development even in antiquity and Nigeria.

**Key Words:** Heterosis, consanguinity, livestock and human populations, antiquity, Nigeria

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#### INTRODUCTION

It is important that definitions of some key words are noted here as they would deepen one's understanding of the arguments being put forward here. The key words are heterosis or exogamy, and consanguinity or endogamy. It is pertinent to understand that the terms heterosis and exogamy refer to the same idea with regard to the product, whether of plants, animals or humans. Therefore, heterosis and exogamy, having been defined, would be used interchangeably in the study, the same for the words- consanguinity and endogamy.

Heterosis is the tendency of a crossbred organism to have qualities superior to those of either parent. Heterosis also means hybrid vigour. The English Oxford Living Dictionary defines heterosis as hybrid vigour. The Merriam Webster Dictionary renders heterosis as “the marked vigour or capacity for growth often exhibited by crossbred animals or plants — called also hybrid vigour.” Exogamy is marriage to a person belonging to a tribe or group other than your own as required by custom or law. Shull (1914) defined heterosis as the genotypic differences in two uniting gametes which lead to stimulation of cell-division, growth and other physiological activities of the hybrid (organism) over its originating parents.

On the other hand, the Cambridge dictionary defines consanguinity as the “condition of being blood relations (relations by birth, not marriage).” The English Oxford Living Dictionaries defines it as “The fact of being descended from the same ancestor”. Consanguinity, which is also endogamy is a relationship between two people of the same lineage. Shamel (1905), outlined consanguinity or inbreeding in plants as the “fertilization of a flower with its own pollen, with pollen from another flower on the same plant, or with pollen from a closely related plant.” Such plants include; wheat, oat, barley and tobacco. Bamberg (2017) expresses consanguinity as a gender-neutral term for fraternity or sorority. Inhorn et al. (2009) described consanguinity as marriage between a male and female with the same ancestor not more distant than great-great grandparents. Inbred children are the products of consanguineous relationships or marriages. Bittles et al. (2002) and Bittles et al. (1991) further stated that consanguinity does increase the rate of homozygosity in offspring such that they become at great risk of recessively inherited disorders.

In endogamy, the relationships are usually marriage or sexual relationships between relatives even up to the fourth degree. The first degree being that between a parent and child; the second degree is that between siblings; the third degree is between cousins; the fourth degree is that between first cousins. Bouchard (2010) noted that the Catholic Church forbade marriages between relatives who were in the categories of the first to the fourth degrees. Bouchard (1981) also states that in the 9th century AD, the Church extended the illegality of consanguinity to the 9<sup>th</sup> degree. Therefore, nobles had to remove far hence to get suitors. The consequence of this was that new noble families were created. The aforementioned definitions throw light on the differences between heterosis and consanguinity.

Scholars have examined, independently, heterosis and consanguinity in plants, animals and humans. However, there is little or no study that presents a side by side investigation of heterosis and consanguinity in animals and human populations. This study sets out to accomplish this objective with a view to understanding how these cultures/strategies can positively or negatively affect the populations mentioned in the progress and prosperity of a society whether in antiquity or modernity. In so doing, the historical and comparative methodologies are adopted. The Social Development theory that explains the quality changes that occur in the structures and frameworks of a society which aid society's growth, progress and prosperity is adopted. The Greco-Roman and Nigerian societies are placed in perspectives with regard to this study.

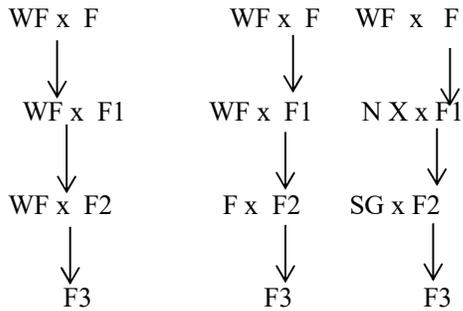
#### HETEROSIS IN ANIMAL POPULATIONS

Two broad methods of breeding exist in animal production, namely, inbreeding and outbreeding. The former entails mating animals that share a common ancestry while the latter entails the opposite. The primary objective of livestock improvement through strategic breeding methods is to improve feed conversion, improve egg production, achieve better body conformation, improve survivability and livability, improve palatability of livestock products and generally improve profits and returns on investment. The broad objective is often to ensure that animal products get to the end user at the least cost without compromising quality. On this journey of livestock improvement, inbreeding becomes useful at some point while outbreeding becomes useful at some other point.

DIFFERENT FORMS OF INBREEDING: BACK CROSSING AND CRISS-CROSSING

A back cross entails mating progeny to a desirable parent to further concentrate and harness the good traits of a desirable parent. Take a cross between purebred Friesian cattle and purebred White Fulani cattle.

**Fig.1: Diagrammatic depictions of a back cross, a criss-cross and a rotational cross.**



WF=White Fulani; F= Friesian; SG= Santa Getrudis; F1= First filial generation; F2= Second filial generation; F3=Third filial generation.

**Source: Ibe (1998); Essien and Adesope (2003)**

While the back cross is a kind of line cross that seeks to increase the proportion of White Fulani blood in preference to Friesian (F), the third cross, which is called a rotational cross, entails introducing a new breed of cattle at each filial generation. Rotational crossing generates the highest heterozygosity. The first and second crosses (back crossing and criss-crossing) are forms of inbreeding while the third cross (often referred to as a rotational cross) is a form of outbreeding and hence generates the greatest heterozygosity. Notice that in the first two crosses only just two breeds are involved from the first, second to the third filial generations; White Fulani and Friesian. In the third cross (the rotational cross) a new cattle breed is introduced at each filial generation. This increases heterozygosity and diversity

**Heterosis:** This is the edge that the F1 in a cross between two purebred lines or breeds or strains has over their parents. We can have positive, negative or zero heterosis. When the F1 is better than the mean of both parents, the F1 is said to have mid-parent heterosis. If the F1 is lower than the parents, the F1 will be said to have ‘negative’ heterosis. If the F1 is neither higher nor lower than the parental genotype, there is zero heterosis. When the F1 has positive heterosis, it is said to possess hybrid vigour. It should be noted that we can have individual heterosis, maternal heterosis and paternal heterosis.

The discourses on heterosis and consanguinity have provided insight into the benefits of both themes with regard to animal and human populations. Farmers who discovered the importance of heterosis have continued to adopt the method for yield increment in their products. Rajesh et al. (2015) confirmed that the goal of crossbreeding is heterosis or hybrid vigour in animals. They attest that heterosis has been used by commercial farmers in beef production to “enhance fertility, longevity, growth and meat quality in commercial herds,” and that without this heterotic strategy, low improvements in survival of livestock would be witnessed. Theunissen *et al.* (2013) attempted to draw the attention of all to crossbreeding and its attendant advantages for cattle farmers and the promise it holds for a reduction in the unit cost of beef production, profitability and sustainability for beef farmers, even in Southern Africa. While heterosis is advantageous when two organisms are crossed, vigour may decrease if the hybrids are mated. Therefore, it is important that for heterosis to be beneficial, the parental lines remain maintained. Munaro *et al.* (2011), explained that increase in grain yield can be linked to a heterotic strategy in the production of grain in relation with the environment. Wakchaure *et al.* (2015) further noted that

heterosis in animals have considerable positive consequences such as improved growth, reproduction, production and maternal traits, health and overall fitness of the animals. While highlighting three types of heterosis; individual, maternal and paternal heterosis, they further state that fertility, milk yield and longevity are better enhanced through crossbreeding rather than through pure breeding, and that in order to retain high levels of heterozygosity and heterosis in composite breeds, inbreeding must be avoided. They conclude that heterosis is successful when the crosses are indeed superior over the purebreds, and that heterosis is normally practiced in poultry, swine and sheep where fertility is high and the replacement of purebred stock is essential and uncomplicated. Heterosis consequently proffers great yield in animal production, which in turn, benefits man and his society. The idea that heterosis is more beneficial to animals than consanguinity is expressed by Pimm *et al.* (2006) in their study to determine the survival rate of hybrid panthers to purebreds in South Florida, they examined the consequences of introducing panthers from Texas into South Florida, in an area with a minor, isolated, inbred and distinct subspecies of panthers otherwise known as the Puma concolor coryi. Prior to this period, panthers in South Florida with a large population, had become isolated, their numbers had declined, while genetic defects had increased. In order to reverse the genetic damage, the zoo managers introduced eight female panthers from Texas into South Florida in the mid-1990s. Pimm *et al.*, studied this transplantation of panthers. The result of their study showed that crossbreeding occurred, and more hybrids reached adult age than purebreds. Then they compared the survival rate of purebreds and hybrids from kitten to adult age. Out of 118 purebreds and 54 hybrid kittens, 13 purebreds and 20 hybrids survived from kitten to adult. The fact of the matter is that heterosis was more beneficial in the case with the panthers than consanguinity with regard to survival, hybrid vigour and of course, preventing the panthers from extinction. Frankham (2015) notes that outcrossing of inbred population was advantageous in 93% of 156 cases studied. Furthermore, outcrossing was 148% beneficial in wild environments and 45% in benign (captive) environments whether in plants or animals.

#### HETEROSIS IN HUMAN POPULATION

Exogamy (which is also heterosis, but often used with reference to human population) refers to marriage between couples who are not genetically related. Thornhill (1993) states that people naturally engage in exogamy and that exogamy reduces the risk of children being bedevilled with genetic defects as a result of recessive genes derived from the parents. Dorsten *et al.* (1999) mention that maladaptive genetic defects are inherited by children of parents who engaged in endogamous marriages or relationships. They further state that partners who avoided incestuous marriages were likely to have healthier children. Heterosis indeed brings about healthy offspring in humans.

It is argued that heterosis, whether in plants, animals or humans refer to genes that cause fitness in organisms. Two main hypothesis that explain this fitness advantage are; the Over-Dominance hypothesis and the Avoidance of Deleterious Recessive Genes hypothesis. The Over-Dominance hypothesis explains that offspring of parents of different “genetic backgrounds will have greater resistance to a broader spectrum of potential health dangers” (*ibid*). This is due to the fact that separate genes make up the parents, unlike the case of parents who descend from the same genetic pool and so possess low immunity against health dangers. The Avoidance of Deleterious Recessive Genes hypothesis posits that “an organism that descends from parents of different genetic backgrounds will have fewer harmful recessive genes.” This is unlike the case of parents from the same genetic pool. The implication for this is that fewer harmful recessive genes can cause fitness in an organism. Khan (2011), noted that the more dissimilar parents are, the taller and stronger the offspring. He documents that this can occur when heterosis is put into practice in the sense that parents must descend from different genetic pool. And this can occur when parents are from distant places or come from different geographical locations.

Koziel *et al.* (2011) argued that the distance of parental birthplaces, mid-parental height and socioeconomic status had significant and positive effect on height in boys and girls aged 6 to 18 years from Ostrowiec Świętokrzyski, Poland. The result of this study demonstrated that heterosis is an important contributor to human growth and development in a given society. Kaeppler (2012) made the distinction between heterosis and inbreeding in plants, animals and human populations, while also discussing the various genes that contribute to heterosis and the merits and demerits of each theme towards the growth and development of a society. Kaeppler concluded with the thought that heterosis is the “. . . result of the diversity of genes, pathways, and processes known and yet to be discovered.” Davenport (1970), did express through his research, that miscegenation provided results which are a shift from what obtains today with respect to research done by scholars on heterosis and its positive impact on humans, animals and plants. Several other literatures have all considered and demonstrated that heterosis in animal and human populations is indeed very beneficial.

#### CONSANGUINITY IN ANIMAL POPULATIONS

It has been noted that the demerits of consanguinity in animal populations far outweigh the merits. One of the merits in consanguinity is that the purity of the gene pool keeps inbred from extinction. But can we depend on this situation and for how long? For research has, more often than not, demonstrated that consanguinity in animal populations has more disadvantages than advantages towards animal growth and production. Xinyu Li (2014) noted the consequences of consanguinity in captive animal populations. The consequence is inbreeding depression and under inbreeding depression, two categories of reduced reproduction and lower survival rates are documented. Under reduced reproduction, factors such as “reduced litter size, abnormal male reproductive development, poor semen quality, reduced fertility, reduced female reproduction and reduced successful breeding” are discovered. In the case of lower survival rate, factors such as “decreased longevity, decreased viability and juvenile survival and increased infant mortality are noted. Charlesworth and Willis (2009) stated that inbreeding can cause several disabilities such as reduced fertility in litter size and sperm viability, higher infant mortality, reduction of immune system function etc. Several other scholars confirm that consanguinity in animals, has negative effects in the development and growth of animals. Yet some scholars, in non-human studies, attest to some advantages of consanguinity in animals such as decorated crickets (*Grylloides sigillatus*) and dampwood termites (*Zootermopsis angusticollis*). This advantage of inbreeding is that it has positive effects on immunity. Gershman *et al.* (2010), stated that inbred of decorated crickets have the ability to encapsulate foreign bodies than outbred. Rosengaus and Traniello (1993) discovered that colonies started by nestmates of dampwood termites have considerably higher survival rates than colonies began by pairs of non-nestmates. In spite of this, consanguinity is not as advantageous as heterosis in animal and human populations. This is not the case with majority of animals. Crickets and termites do not add that much of culinary value to man.

#### CONSANGUINITY IN HUMAN POPULATIONS

In human populations, consanguinity causes inbreeding depression as well as high risk of diseases. Bener and Mohammed (2017), state that consanguinity increases the risk of ominous and debilitating diseases such as diabetes mellitus, cancer, blood disorder, asthma, gastro-intestinal diseases, hearing deficit and eye disorder among others. Lyon *et al.* (2009), mentioned that inbreeding depression in humans is a risk factor in susceptibility to infectious diseases in humans such as tuberculosis and hepatitis. Shawky *et al.* (2015), through intensive research of a population with consanguineous unions, link various disorders and diseases to consanguinity and consequently, advocates public health education and counselling in genetics in the said community. These disorders and disease include; recessive disorders (78.8%), multifactorial disorders (69.8%), chromosomal disorders (29.1%), mental retardation (100%), limb anomalies (92.6%), stillbirths (80.6%), child deaths (80%) and recurrent abortions (67%). Consanguineous marriages increase deleterious lethal genes which are inherited from

ancestors, passed on to inbred and cause these afore mentioned disorders. Erzurumluoglu *et al.* (2016) analysed consanguineous populations through a gene-centric approach. They explain that understanding how genes work can aid in knocking out deleterious genes such that one can understand how to analyse consanguineous populations and determine its health effects on such populations. Consanguinity in human population has more disadvantages than advantages. The advantages are more of economic than genetic, while the disadvantages demonstrate how consanguinity does not augur well for human populations.

However, some scholars (Bittles, 2012; Hamamy et al. 2011), mentioned some potential functions or advantages such as stability of the family, maintenance of income and wealth etc. Bhopal *et al.* (2014) state some presumptive social benefits of consanguineous marriage, which are “financial stability, marital stability, transmission of cultural values and cultural continuity, uniting the members of the descent group, maintenance of family structure and property, ease of arrangements for arranging marriage and reducing uncertainties about care for extended family members in ill-health.” This study compared consequences of consanguineous unions among Pakistani, other ethnic groups, and White British groups not in consanguineous unions in the United Kingdom. The result demonstrated that 59.3 percent of women in the Pakistani group were blood relatives of their baby’s father. Mothers in consanguineous group were socially and economically disadvantaged compared to the other groups not in consanguineous relationships. However, the social, economic and healthy lifestyle of these Pakistani women in consanguineous unions were the same, and in some cases better than women in other exogamous unions. Divorce and a lifestyle of smoking in pregnancy were very low in women in endogamous unions as compared to women in the other groups. In spite of this study by Bhopal *et al.*, should endogamous relationships be encouraged? The scholars indicated social and economic benefits which were only slightly higher than what obtained in endogamous unions. It is not clear whether the non-smoking attitude of pregnant women was as a result of consanguineous unions. It seems quite probable that it was the function of the customs and culture of the Pakistanis. Creighton (2014) who advocates against consanguinity, notes that inbreeding also has advantages, in that, genetics conditions that are beneficial are likely to be passed on to inbred. Creighton notes that offspring from a group of inbred in Japan demonstrated a 14.3% reduction in allergies and a 23.9% reduction in nephritis, a rare genetic disorder that causes inflammation of the kidneys. Some other scholars (Denic et al., 2007; Hedrick 2012; Denic et al., 2008; Denic et al., 2008) argued that consanguinity can cause fitness in a population with endemic malaria. They contend that consanguinity increases the prevalence of  $\alpha^+$ -thalassemia which is resistive or protective against malaria in inbred. However, it increases other deleterious diseases that cause fatality in inbred due to an increase in homozygosity of recessive lethal alleles. In spite of these, one would rather choose heterosis over consanguinity; one would choose a healthy life over an unhealthy one.

#### HETEROSIS AND CONSANGUINITY IN ANIMAL AND HUMAN POPULATIONS IN ANTIQUITY AND NIGERIA

Transhumance/agro pastoralist debate has clearly demonstrated that animal husbandry was considered important as it served several social, environmental, economic, and political interests in antiquity. Howie (2012), put forward the argument that ancient Greek communities such as Athens, Sparta, Thessaly, Arcadia and Central Greece devised and adopted varying methods of animal management for the purpose of the social agenda of each of these communities. Ancient authors such as Aristotle, Collumella and Varro did mention animal breeding in antiquity. They made references to the nature of horses, mules and others when discussing several aspects of the society. However, the idea of heterosis and or consanguinity in animals was rarely mentioned, probably due to the argument that it had not been discovered or studied. For many suggestions by ancient authorities on effective animal breeding and production do not include references to heterosis or inbreeding. Valenzuela Lamas, S. and Albarella (2017), attested to animal husbandry in pre and during Roman antiquity. They attested to instances

when animals decreased in number in some places and increased later at other times. They suggested that these fluctuations were probably due to consolidations and territoriality of other cities by the Romans. The point to note here is that during the period of Roman antiquity, the people devised and also adopted methods and some kinds of animals they could manage for their own benefits. In some climes, pigs were preferred, while in others, cattle was favoured. Beginning from the Mycenaean world to the world of late Roman antiquity, animal husbandry did not feature the subjects of heterosis and consanguinity; and even if it did, it did not obtain the sort of focus these themes are being subjected to in today's modernity and scholarship.

In human populations, Greco-Roman ancient authorities such as Plutarch (1927), Plato (1955), are both unanimous in the condemnation and rejection of consanguinity in the society. The Greco-Roman societies forbade and did not tolerate such practice. It could be due to the incest taboo. The rationalizing of the idea as horrible by philosophers tended to prove that.

The Nigeria experience is indeed a deviation from those of the Greco-Roman. Several scholars (Nwachukwu et al., 2012; Nwachukwu & Okoji 2012; Swallow & Jabber 2018), have examined and discussed heterosis and consanguinity in animals in Nigeria, and how heterosis or cross breeding has indeed enhanced production in yogurt and other dairy products, and increase in beef production in various parts of the nation. Habibu Umar Aminu (2015), in an interview with Alhaji Umar Ya'u Gwajo-Gwajo, noted that cross breeding sheep, goat and cattle from Sudan, Jordan and Niger Republic with the ones in Nigeria, has indeed added value to their animals in the sense that the hybrids are stronger than the purebred and also there is evidence of high-quality meat and milk. Nwachukwu (2018), while discussing the various kinds of methods to adopt for successful breeding, mentioned different kinds of breeding sheep and goats in Nigeria such as (for sheep); balami, uda, yankasa and West Africa Dwarf; and (for goat), sahelian, Red sokoto or maradi and the West African dwarf goat which were crossed with breeds from other states of Nigeria, Niger and Chad Republics as well as exotic breeds from Australia, New Zealand and other Western countries. It is certainly obvious that animal farmers in Nigeria have adopted heterosis due to its advantages. Adebambo *et al.* (2011), while making genetic distinctions between two goat breeds in Nigeria established that cross breeding or a heterotic strategy for goat breeds does increase milk and meat yields for the livestock farmer in Nigeria.

Nigeria largely practices exogamous marriages, probably due to the abhorrence of incest. However, the Fulani in Nigeria are known to practice endogamy evidenced in cousin marriages. It is pertinent to note that in spite of the rejection of endogamy by majority of Nigerians, some people have been seen committing incest. In Nigeria, incest is more a social or cultural vice than a healthy misnomer for many are unaware of its disadvantages genetically.

## CONCLUSION

Having considered all of the above aspects of this paper, one may question the essence of the themes with regard to Greco-Roman antiquity and Nigeria. The aim of this paper is to argue that heterosis in animals and humans is one of the means to build a peaceful, strong and effective populace and in fact, a prosperous and progressive society.

It has been noted that the consequences of heterosis in livestock include; hybrid vigour, increment in the production of milk, cheese, yoghurt and meat, liveability etc. And the consequences of heterosis in human include hybrid vigour, etc. Imagine if a man with hybrid vigour consumes livestock of hybrid vigour, we would be looking at a healthy populace with strong and healthy soldiers who, if properly trained, would defend the city against attacks. Therefore, it is important that contemporary Nigeria understands it and latch unto it for practice and then perfection. Greco-Romans probably did not understand these aspects of genetics, even though they did care for their livestock. However, both societies were objected to consanguinity. They were totally against sibling marriage. Imagine if the

Greco-Roman world had understood heterosis and consanguinity and how to establish the link between both themes, they probably would have developed their soldiers better than what they were then and what they were capable of. Nigeria today is on a better stead. This study recommends that where it is possible, exogamy must be encouraged in Nigeria. The Fulani who practice endogamy should be encouraged to accept and welcome members of other ethnic group into their society. This would minimize tension between Fulani and non-Fulani in Nigeria. The Yoruba and the Igbo have intermarried and so it will be very difficult, if not impossible for the Yoruba and Igbo to get involved in any bloody conflicts relating to ethnicity. This is a consequence of exogamy.

Adopting the Social Development theory, the argument being put forward here is that today's Nigeria can attempt to institutionalize this system of social development with regard to heterosis in both animals and human populations in Nigeria as it would help in providing an effective nation. The Social development theory attempts to explain the quality changes that occur in the structures and frameworks of a society which aid society's growth, progress and prosperity. Society taps into these opportunities that place the society on a strong and effective footing for the betterment of the people. Therefore, social development has been observed to have occurred, beginning from the earliest society, evolving with the times and seasons, even as societies exploited every opportunity and upgraded the society to higher levels of development.

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