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Prospects for utilization of the relationship between zoometrical measurements and performance traits for poultry and livestock genetic improvement in developing countries

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ABSTRACT

The preceding review looks at the prospects for utilization of the relationship between zoometrical measurements and performance traits for poultry and livestock genetic improvement in developing countries. Improvement of poultry and livestock indigenous to developing countries is paramount in order to increase their contribution to the much needed animal protein due to human population increase in this part of the world. However, this is on the background that the estimates of genetic parameters for performance traits in poultry and livestock are scarce in developing countries because of failure of most attempted selection schemes, which has been exacerbated by the problems of measuring of performance traits due to lack of appropriate technologies. Assessment of the performance of poultry and livestock species is done using various indices, most especially on growth and development traits as well as body conformational traits. The significant genotypic correlations between the body weight and the zoometrical measurements and the heritability of the body weight at various stages of livestock production indicate a systematic cause which can be important to consider for livestock breeding and selection purposes. In case, where the genetic correlations between zoometrical measurements and performance traits of concern are positive and high this implies that the traits are genetically linked. Morphological properties can provide to some extent a reasonable representation of the differences among the genotypes within the same species, though not exhaustive, it serves as the foundation upon which DNA analysis can be built. Selection for improved production within poultry and livestock breeds or ecotypes is problematic for one of the following reasons: for effective selection depends on accurate recording of pedigree and performance traits. The complexity of measuring some of the performance traits due to lack of necessary equipment or technology presents considerable obstacles to effective selection for improved performance in developing countries. Unlike the developing world, recently, DNA analysis through molecular markers has provided an invaluable new technology in poultry and livestock improvement for determining the relationships among individuals, breeds and ecotypes. To increase meat yield from poultry and livestock breeds in developing countries require genetic improvement of their live weight and other performance traits which have a history of relationship with linear body measurements. Proper measurement of live weight as a performance trait, which is often hard with resource poor rural farmers due to lack of weighing scale, is requisite for achieving this goal. The need for estimation of live weight from simple and more easily measurable variable such as zoometrical measurements therefore arises. Therefore, the use of zoometrical measurements which are simple to measure and are highly correlated to desirable performance traits is feasible option for livestock genetic improvement in developing countries. The relationship between zoometrical measurements and performance traits, apart from being used for breed characterization should rather be used for pro poor poultry and livestock improvement ventures in developing countries, which are mainly constrained by lack of modern animal improvement technologies. Poultry and livestock improvement specialists need to establish the relationship that exists between easily measureable zoometrical measurements with performance traits and to organize the genetic improvement programmes so as to achieve optimum poultry and livestock performance for maximum economic returns in developing countries.

1. Introduction

The various zoometrical measurements related to body lengths, heights and girths of live animals were measured to assess the relationship between these variables and the live weight for breed characterisation in different animal species: in cattle (Dineur and Thys 1986; Goe et al., 2001; Mekonnen and Biruk, 2004; Abdelhadi and Babiker, 2009), in sheep (Valdez et al., 1997; Atta and El Khidir, 2004; Sowande and Sobola, 2008; Kunene et al., 2009; Oke and Ogbonnaya, 2011) or goat (Mohammed and Amin, 1997; Nsoso et al., 2004; Adeyinka and Mohammed, 2006; Fajemilehin and Salako, 2008), however, in these studies non of the zoometrical measurements taken were used for poultry or livestock genetic improvement purposes. Determining animal live body weight, linear body measurements, and their inter-relationship and correlation is imperative for determining genetic potential, breed standards, and improved breeding programs for higher meat production (Younas et al., 2013). The phenotypic variability in zoometrical measurements as much as performance traits in livestock production are affected by both genetic and environmental factors (Semakula et al., 2011). Genetic selection has led to improved growth rate, feed conversion and increased meat yield in poultry and livestock production (Sanda et al., 2014; Edward and Denman, 1975; Boukwamp et al., 1973). Relationships between body weight and zoometrical measurements are important for predicting body weight and can also be applied speedily in selection and breeding programmes. The use of body measurements to predict body weight of different animal species (e.g. cattle, sheep and goat) have been done by some authors (Attah et al., 2004; Sowande and Sobola, 2007; Goe, 2007). Zoometrical measurements have heritable basis and play a major role in the subsequent carcass yield of an animal (Falconer, 1989). Therefore, the relationships between the body measurements are needful for the prediction of other performance traits in animal (Cecchinato et al., 2009). The preceding review looks at the prospects for utilization of the relationship between zoometrical measurements and performance traits for poultry and livestock genetic improvement in developing countries.

2. Genetic parameters for zoometrical measurements in poultry and livestock species

Heritability is the proportion of phenotypic variation in a population that is attributable to genetic variation among individuals. The low heritability could be attributed to the environmental influence on the trait, additive gene action and the small sample size. The knowledge of genetic parameters is one of the pre-requisites for genetic improvement for economic traits (Akanno and Ibe, 2006). The genetic correlation among the linear parameters and the study of heritability are important genetic parameters for optimizing and evaluating crossbreeding systems. These genetic parameters are especially needed in selection method to achieve genetic progress. Sanda et al. (2014) studying different chicken strains in Nigeria reported that heritability estimates (h2) for body dimensions carried out on the chicken strains ranged from low to high. In the same study it was observed that Marshall broiler chicken strain had the highest h2 for body weight 0.46±0.04, followed by Arbor Acre and Ross with h2 being 0.38±0.12 and 0.26±0.06, respectively. The repeatability estimates for body weight in the three broiler strains were high, and it ranged from 0.70 at week 4 to 0.88 at week 10. Furthermore, relationships between the body weight and linear body measurements in the broiler chicken strains were positive and highly significant. Berry et al. (2004) assessing the phenotypic and genetic (co)variances among type traits, milk yield, body weight, fertility and somatic cell count in primiparous spring-calving Holstein-Friesian cows reported that the heritability estimates for the type traits varied from 0.11 to 0.43. Blackmore, et al. (1958) studying patterns of growth relationships from body measurements at 6 mo., 1 yr., and 2 yr. of age in Holsteins, reported phenotypic correlations between measurements on the same animal, phenotypic correlations between one measurement on the dam and another on the daughter, genetic correlations, and heritabilities were calculated and considered. It was concluded that the influence of genetic factors relative to that of environmental factors increased with age. The effect of general factors was most evident at 6 mo., whereas the effect of group and specific factors became more evident as age increased.

Estimating genetic parameters for body weight and five body measurements (body length, heart girth, height at withers, height at back and scrotal circumference for an experimental population of Iranian Makooei sheep maintained at the Makooei Sheep Breeding Station at Makoo, Iran, Abbasi and Ghafouri-Kesbi (2011) reported heritability estimates of 0.22±0.08, 0.11±0.06, 0.21±0.07, 0.17±0.06, 0.17±0.06 and 0.32±0.10 for yearling weight, body length, heart girth, height at withers, height at back and scrotal circumference, respectively. These estimates indicate that selection in Makooei sheep would generate moderate genetic progress in body weight and body measurements. The genetic parameters were derived using a multi-trait animal model using the DXMUX program of DFREML software package. In the same study, scrotal circumference, as an indicator of reproductive potential, exhibited the highest heritability. This trait, therefore, could successfully be used to increase productivity of males and, indirectly, female fertility. Janssens and Vandepitte (2004) working on different body measurements and linearly scored traits in Belgian Bleu du Maine, Suffolk and Texel sheep reported heritabilities of measured traits which ranged from 0.26–0.57 and genetic correlations between these traits were high. The measured traits included body weight, height, length, body depth, loin width, heart girth and cannon bone girth. In another study of the same sheep breed the direct heritability has been estimated at 0.17, 0.17, 0.11, 0.21 and 0.22 for height at withers, height at rump, body length, heart girth and yearling weight, respectively, by Abbasi & Ghafouri-kesbi (2011) in Makuie sheep, based on 10 years data. Duguma et al. (2002) who worked on South African Merino rams, reported heritability of 0.40 for scrotal circumference at 16 months of age. Fogarty (1995) summarised h^2 estimates for scrotal circumference in sheep which ranged from 0.08 to 0.50 with a mean value of 0.23. From a literature survey, Matos and Tomas (1992) reported that estimates of heritability for various measures of testis size ranged from 0.00 to 0.75. Jafari and Hashemi (2014) estimating genetic parameters for body measurement and yearling live bodyweight traits in the Makuie sheep breed based on an animal model with the restricted maximum likelihood (REML) approach using a derivate-free (DF) algorithm. It was concluded that the estimates of genetic parameters can be considered a basis for calculating selection indices for body measurements, as well as revealing their association with yearling bodyweight traits. Six animal models were fitted, differentiated by including or excluding maternal effects, and with and without covariance between maternal and direct genetic effects. Ignoring the maternal effects, the direct heritability was estimated as 0.20, 0.24, 0.10, 0.14, 0.02 and 0.36 for height at wither, height at rump, body length, heart girth, leg circumference and yearling weight, respectively. The estimates were slightly higher when maternal effects, genetic or environmental, were ignored in the analyses. Using bivariate analysis, the estimates for additive genetic correlations ranged from 0.56 to 0.81 among the studied traits. In the same study, a log-likelihood ratio test was used to select the most appropriate univariate model for each trait. Based on log-likelihood ratio test, the direct additive genetic and maternal permanent environmental effects were regarded as an important source of variation of the studied traits. In another study of the same sheep breed the direct heritability has been estimated at 0.17, 0.17, 0.11, 0.21 and 0.22 for height at withers, height at rump, body length, heart girth and yearling weight, respectively, by Abbasi & Ghafouri-kesbi (2011) in Makuie sheep, based on 10 years data. Mandal, et al. (2008) estimating co(variance) components for body measurements at birth and weaning in Muzaffarnagari sheep using REML procedure, while fitting an animal model and ignoring or including maternal genetic or permanent environmental effects. Six different animal models were fitted for linear body measurements. Direct heritability estimates were inflated substantially for all traits when maternal effects were ignored. The direct heritability estimates for body length, height at withers and heart girth of lambs at birth were 0.14, 0.14 and 0.07, respectively. The corresponding maternal heritability estimates for these traits at birth were 0.13, 0.15 and 0.13, respectively. Moderate estimates of the direct heritability (h^2) and the fraction of variance due to maternal permanent environmental effects (c^2) for body length ($h^2=0.12$, $c^2=0.08$), height at withers ($h^2=0.16$, $c^2=0.08$) and heart girth ($h^2=0.15$, $c^2=0.09$) was observed at weaning. It was concluded that maternal additive effects were only important at birth for these traits but permanent environmental maternal effect had some influence on body measurements at weaning. These results indicate that modest rates of genetic progress appear possible for body measurements at birth and weaning. Caution should taken in modeling zoometrical measurements for their low coefficients of variation which were observed (Jafari and Hashemi, 2014). However, other studies have also reported low coefficient of variation which could be explained by the small differences among the animals of the population, greater uniformity of the traits, minor changes in these traits by environmental qualifications, better response to selection and other unknown factors(Fourie et al., 2002; Ermias and Rege, 2003; Alfolayan et al., 2006; Salako, 2006).

For linear body measurements in rabbits, estimate of heritability as reported by Chineke and Adeyemi (2001) ranged from 0.90+1.46 for length of ear at 56 days to 0.99+0.48 for shoulder to tail at 49 days. Akanno and Ibe (2006) estimating genetic and phenotypic correlations using appropriate expressions involving the estimated variance components according to Becker (1984), observed moderate to high estimates for body length at 6, 9 and 12 weeks, for head to shoulder at 9 and 12 weeks and shoulder to tail and length of leg at 9 weeks. This was in agreement with estimates reported by Chineke and Adeyemi (2001) and indicate the potentials for genetic improvement of rabbits through individual selection. The traits studied reflected the length of long bones, which have been observed as good predictors of live weight and carcass composition (Tiamiyu et al. 2000). Not all heritability estimates could be derived for example for estimates from PHS for head to shoulder and length of leg at 6 weeks and ear length at 9 and 12 weeks which was as a result of negative sire variance components in the analysis of variance. Negative variance components are regarded as an indication of negligible contribution of additive genes to variation of the traits concerned. Although theoretically impossible, negative variance components may result with analysis of variance procedure of estimation.

3. Correlation of zoometrical measurements with performance traits in poultry and livestock production

Several studies reported a strong correlation between some linear body sizes with some production traits, i.e. linear body size can be used to estimate the body weight of sheep (Otoikhian et al., 2008; Abdel-Moneim, 2009) and goats (Mukherjee et al., 1981, 1986; Singh et al., 1987; Adeyinka and Muhammad, 2006; Jimmy et al., 2010). Also, it can be used to estimate some properties of lamb carcass trait (Abdel-Moneim et al., 2009), or to estimate the litter size in goat (Marai et al., 2006). Mukherjee et al. (1981; 1986) and Singh et al. (1987) reported the highest and significant correlation value of bodyweight with chest circumference in brown Bengal does and grey Bengal goats, respectively. At later stages (from 19-24months and onward) the body length assumes more importance as an indicator of live weight (r = 0.701, r = 0.779). In conclusion, since the body measurements had high correlation with the body weight, this may be used as selection criteria. Genetic correlations among some type traits were very strong and may indicate the possibility of reducing the number of traits assessed on each animal; the genetic correlation between angularity and body condition score was –0.84 (Berry et al. 2004). The study revealed that genetic correlations between all type traits (except body condition score, udder depth and teat length) and milk yield were positive and ranged from 0.08 to 0.69. This implied the possibility of selecting for body weight may be achievable within a national progeny-testing programme using type traits within a selection index. Moderate to strong genetic correlations existed between some type traits and the various fertility measures and somatic cell count indicating the opportunity of indirect selection for improved fertility and health of animals using type traits within a selection index; however, the standard errors in their study of some of the genetic correlations were large and should thus be treated with caution. It was concluded that genetically taller, wider, deeper, more angular cows with tighter, stronger, shallower udders were predisposed to have inferior pregnancy rates to first service and require more services. Moruppa and Ngere, (1986) reported high and significant correlation coefficient between height at withers and heart with body weight which implied that either of this variable or their combination would provide a good estimate for predicting live body weight in Beetal goats at an early age. The higher coefficient of correlation were (r = 0.638 and r = 0.552) for height at withers and heart girth , respectively. Similar trend was also reported in Red Sokoto goats Osinowo et al (1989). These values are with no respect to affect the sex of goat on the variable.

The correlation of body weight and linear measurements were positive in three pig genotypes. The chest girth and height at withers had the highest and strongest relationship (r=0.83, 0.82 respectively) with body weight among other linear measurements (Morenikeji et al., 2013). Cecchinato et al (2009) suggested that the positive and high genetic correlations obtained between various linear measurement and body weight were consistent since the body weight is the overall body growth, which itself is the sum total of increase in size of different structural body components. It also indicates the pleiotropic action of genes responsible for these characters. Other implications of this also mean that genetic improvement could be made possible by direct selection for any of the measurements as the responses are correlated. Odubote and Akinokun (1991) and Ozoje and Mgbere (2002) in goats and sheep, respectively, reported that as the chest girth increased, there was a corresponding increase in the body weight of the animal. Yahaya et al., (2012), and Alabi et al., (2012) reported that high positive correlation exist between body weight and linear body measurements in broilers and naked neck/venda chickens of South Africa, respectively. Earlier reports also indicated that selection based upon the body measurements should improve the meat production (Bhattacharya, et al., 1984; Bose, S., Basu, S. B., 1984). However, it was suggested that further research was needed to investigate the relationship between the body weight with linear body measurements in same and other breeds of goats in different region of the country at different age with maximum number of observations. The recorded zoometrical measurements had a strong positive correlation with birth weight, indicating that they can be used to estimate birth weight in Hissardale sheep of varying ages under field conditions (Younas, et al., 2013). Body measurements have been used to predict body weight by several authors in many breeds of sheep (Aziz and Sharaby, 1993; Enevoldsen and Kristensen, 1997; Riva et al., 2004; Iqbal, 2010). However, suggested that different models might be needed to predict body weight in different environmental conditions and breeds. Correlation values were seen positive and significant in height at withers, body length and heart girth (Topal and Macit, 2004; Cam et al., 2010).

Akanno and Ibe (2005) reported genetic and phenotypic correlations which were moderate to high and positive between the various traits in rabbits except for the negative values obtained for genetic correlations between individual body weight and head to shoulder (-0.12), and individual body weight and body length (-0.01) at 9 and 12 weeks of age, respectively. Abbasi and Ghafouri-Kesbi (2011) reported positive genetic correlations Iranian Makooei sheep which ranged from 0.15 (yearling weight/height at back) to 0.99 (height at withers/height at back). Phenotypic correlations were also positive and ranged from moderate (0.32, height at withers/scrotal circumference) to high (0.94, height at withers/height at back). Positive genetic and phenotypic correlations indicate that improvement in body measurements both at the genetic and phenotypic levels is expected through selection on body weight and vice versa. Kerketta, et al (2015) measuring linear traits in goats: chest girth, height at withers, body length, pelvic girth , and testicular measurements (testicular circumference, testicular length, testicular width, testicular thickness, and testicular volume) reported that body weight had positive and significant correlation with all body measurements and scrotal biometry. In bucks with age more than 1 year, body weight has positive and significant correlation with total ejaculation. Heart girth is a part of tissue measurements (Blackmore et al., 1958), while other measurements are related to skeletal measurements. It can explain, to some extent, the higher correlation between body weight and hearth girth. Scrotal circumference was positively correlated genetically and phenotypically with other traits and was most highly correlated with body length.Data on bodyweight and linear body measurements namely ear length, heart girth, body length, head to shoulder , leg length and tail length of 178 Chinchilla breed of rabbits at 3, 6 and 8 weeks of age were analyzed to obtain the phenotypic correlation between the various linear body measurements on one hand and linear body measurements on bodyweight on the other (Okoro, et al. 2010). Phenotypic correlation between body weight and linear body measurements ranged from 0.36 - 0.91, 0.47 - 0.82 and 0.34 - 0.71 in weeks 3, 6 and 8 weeks, respectively. This showed that as the animal grows, there was a positive relationship between its bodyweight and linear body measurements . It was concluded that a particular linear body measurement or a combination of it can be used to determine the bodyweight or another linear body measurements of a chinchilla rabbit.

4. Implications

Advances in livestock improvement technologies related to molecular genetics and others require relatively good laboratory equipments which are not available in developing countries, as a result the cost is relatively expensive and local scientists lack adequate mastery of these techniques. Poultry and livestock improvement programmes which focus on the use of positive and high correlated zoometrical measurements with performance traits which are relatively easier to measure and inexpensive when compared to advanced livestock improvement technologies data collection is a feasible option in livestock improvement in developing countries. The implication of the strong and high positive genetic correlation between zoometrical measurements and performance traits in poultry and livestock point to the fact that selection for one trait will lead to improvement in the other. This is the phenomenon of correlated response. Nevertheless, the negative correlations observed in some cases in poultry and livestock indicate that selection for one of the traits could lead to the improvement in the other if a reduction of the second trait is desired. This implies that the choice of zoometrical measurements to employ for selection purposes need to be done with caution. It is undisputable that genetic correlation coefficients are helpful as guides to selection. For example, selection for a wider and longer body in an index could be effective in a breeding programme aimed at achieving increased body size, as long as zoometrical measurements were very highly and positively correlated with targeted performance trait. This is on the background that zoometrical measurements are easily measurable and could be used to predict performance traits for selection purposes. High heritability and repeatability estimates obtained in various studies is a testimony that some zoometrical measurements can be the basis for selection within populations and that fewer records are required to estimate the potential of animals and to realize a high expected response from selection. The important genotypic correlations between the body weight and the zoometrical measurements and the heritability of the body weight at various stages of livestock production are needful for breeding and selection purposes. Different studies in different poultry and livestock species suggest that there are high positive correlations between performance traits and zoometrical measurements. The implication is that targeting some simple zoometrical measurements for selection could lead to an improvement in performance traits. This relationship may be used in selection programme for genetic improvement of poultry and livestock species in developing countries were modern genetic improvement methods are unavailable. Body weight could be predicted, with high degree of accuracy, using simple zoometrical measurements. The relationship between zoometrical measurements and performance traits, apart from being used for breed characterization should rather be used for pro poor livestock improvement ventures in developing countries, which mainly are constrained by lack of modern animal improvement technologies. The moderate to high heritability estimates reported in some studies for zoometrical measurements and performance traits point to the fact these estimates can be successfully used as guides to selection in programmes aimed at improvement of livestock in less developed countries. These estimates reveals that there is substantial variability among individuals in the different breed or species populations which can be utilized for selection purposes where there is high genetic correlation between zoometrical measurements and performance traits. The issue of using different animals models in estimating genetic parameters for different zoometrical measurements could be proposed taking into account the degree of direct and maternal genetic influence on targeted trait. The high additive genetic correlations among the zoometrical measurements with performance traits suggest that genetic progress in the zoometrical measurements and performance traits is possible at the same time.

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