Frequency and influence of some major genes on body weight and body size parameters of Nigerian local chickens

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Abstract

Gene frequencies and influence of four major genes on body weight and body size parameters were studied in populations of adult local chickens in Nigeria. The major genes studied were Naked-neck (Na), frizzle (F), polydactyly (Po) and ptylopody (Fsh). Body size parameters measured were body length, body girth, wing length, keel length, shank length, shank diameter and toe length.

The frequencies of the dominant genes carriers were between 0.02 and 0.03. The values were much lower than the expected mendelian value of 0.75 for dominant alleles. Polydactyl birds were significantly ($P<0.05$) superior in body girth and shank length compared with ptylopod and normal birds. Both polydactyl and ptylopod birds were superior to normal birds in all the measured traits, except for the shank length. Normal feathered birds were superior to Naked-neck and Frizzle birds in most of the metric traits. These superiorities were however not statistically significant ($P>0.05$). The genetic effects of sex on body weight and body size parameters were about the same except that the values for female were negative. The present work suggest that the potential of thermoregulatory Naked-neck and frizzle genes to improve body weight and body size may not be realized in Nigerian local chickens because of their small body size which confers them with a general adaptation.

Management of birds in a controlled environment may help to further prove the superiority of polydactyl and ptylopod birds. It is important to stem the negative selection against the dominant alleles through village level extension service.

Key words: body size, local chickens, major genes, thermoregulatory

Introduction

The tropical environment is characterized by stress factors, notable among which is the high temperature (Ibe 1993) which can lead to heat stress and thus affecting the performance of the animals. Attempts to significantly reduce heat stress problems in poultry through management practices or dietary adjustments have not been successful. Eberhart and Washburn (1993) reported a genetic basis to heat resistance and suggested the need to breed birds with more natural resistance to heat. An earlier attempt to select within flock for heat resistance (Washburn et al 1980) showed a tendency for reduced body weight for birds that were genetically more resistant to heat stress. This calls for other genetic approaches that may not result in decreased body weight.

Certain major genes have been found potentially useful to the tropical production environment either because of their direct effect on production or because of their indirect effect on quantitative trait loci. Among these major genes with indirect effects are the feather distribution (Naked neck, Na) and feather structure (Frizzle, F) genes; both naked neck and frizzle genes have been associated with increased heat resistance (Horst 1988). Marthur and Horst (1990) reported the superiority of individual with frizzle and naked neck genes both singly and in combination over individual with normal feathering for body weight and egg traits.

Pisenti et al (1999) described some mutant developmental defects in chickens that include polydactyly and ptypody. Shoffner et al (1993) observed that line with polydactyly and ptylopody had better body weight and egg production. These major genes, which exist in populations of Nigerian local chicken, could therefore be exploited to broaden the production base of rural poultry. Information that is needed to precedes commercial tread on these major genes are very limited in the country (e.g. Ikeobi et al *19*98). The aims of the present work are to determine the incidence and influence of some major genes on body weight and body size parameters in Nigerian local chicken. The effects of sex on the metric traits were also investigated.

Materials and Methods

The study was conducted on 411 adult local chickens. The birds, which comprised of 183 males and 228 females, were obtained from 100 randomly selected households in eight Nigerian villages. Birds were individually observed for phenotypic expression of feather morphology, feather structure, polydactyly (5 toes) and ptylopody (feathered shank). The number in each group was expressed as a percentage of the total number of birds. The body size parameters measured include body weight, body girth, body length, shank length, wing length, toe length, keel length and shank diameter. Live body weight was measured in kilograms on a top loading weighing scale.

Body length was taken as the distance from the tip of the beak over the neck, through the body trunk to the tail. Body girth was determined as the circumference of the breast region. Keel length was taken as the length of the keel bone from the V-joint to the end of the sternum. The wing length was taken as the length of the wing from the scapula joint to the last digit of the wing. Shank length was taken as the length of the tarso-metatarsus from the hock joint to the metatarsal pad. Toe length was taken as the length of the third toe measured from the metatarsal fold to the last phalange on the toe. The body length, body girth, keel length, wing length, shank length and toe length were measured in centimeters on a tape rule. Shank diameter was determined as the diameter (in mm) of the tarso-metatarsus just below the spur. It was measured using a pair of vernier caliper.

Mean value for body size parameters were subjected to a two-way analysis of variance to determine the effect of the two thermoregulatory genes (Na, F) and sex (Steel and Torrie 1980). The same procedure was repeated to determine the effects of polydactyly and ptyl;pody with sex on the bodyweight and body size parameters. Where statistical differences occurred, mean values were subjected to the Duncan Multiple Range test (Duncan 1955).

The frequencies of the dominant alleles (Na, F, Po and Fsh) and the recessive alleles (na, f, po and fsh) were calculated using the Hardy - Weinberg equilibrium as follows:

q=ãm/t

where:

q = frequency of the recessive gene na, f, po or fsh
m = observed number of birds with recessive trait under consideration
t = total number of birds examined

The frequency of the dominant alleles (Na, F, Po and Fsh) were calculated from p = I - q, where p is the frequency of the dominant allele.

The observed frequencies were tested against the expected Mendelian values of 0.75 for the dominant allele and 0.25 for the recessive allele using the chi-square test. Calculated chi-square value (X^2) was obtained as follows:

The statistical model used to analyse the fixed the effect of sex and genotype was as follows:

Yijk = µ+ gi + sj + eijk

Where:

Yijk = phenotypically expressed trait y (e.g. body weight) taken on the kth individual, of the jth sex, belong to the ith genotype.
µ = overall mean
gi = fixed effect of the ith genotype
sj = fixed effect of the jth sex
eijk = error residual with expectation equals zero.

Where:

: i.. = mean of the ith genotype
: $_{j..}$ = mean of the jth sex
: é =overall mean
b and t = numbers of sex and genotype, respectively.

Results and Discussion

The frequencies of the dominant gene carriers in the population (i.e. naked neck, NaNa + Nana; frizzle, Ff; poly dactyl, PoPo + Popo and ptylopods, FshFsh + Fshfsh) ranged between 3.65 and 5.11 percent, while the frequencies of the recessive gene carriers (i.e. nana, ff, popo and fshfsh) ranged between 94.89 and 96.35 percent (Table 1).

Table 1. Proportion of major gene carriers and their gene frequency in the Nigerian local Chicken

Condition	Major gene	Expected	Observed	Proportion, %	Calculated gene frequency	Expected gene frequency
Naked neck	Na	308.2	15	3.65	0.02**	0.75
Normal	na	102.8	396	96.35	0.98**	0.25
Frizzle	F	274.0	21	5.11	0.03**	0.67
Normal	f	137.0	390	94.89	0.97**	0.33
Plydactyly	Po	295.5*	17	4.00	0.02**	0.75
Normal	po	98.5	377	96.00	0.98**	0.25
Ptylopody	Fsh	295.5*	17	4.00	0.02**	0.75
Normal	fsh	98.5	377	96.00	0.98**	0.25

**only 394 birds were used for evaluation.*
*** Significant difference (p<0.05) from the expected Mendelian ratio*

The gene frequency of the feather distribution gene (Na) was 0.02. Frequencies for the feather structure gene (F), polydactyl gene (Po) and ptylopod gene (Fsh) were 0.03, 0.02 and 0.02, respectively (Table 1).

The expected phenotypic ratio and gene frequencies for the feather distribution gene (F/f) were calculated with the assumption that the number of homozygous dominant individuals (FF) equals zero. This is because the dominant allele is lethal in the homozygous state (Haaren-Kiso et al 1995).

There was a significant genotype effect on the body girth and shank length with polydactyl birds having the highest value (Table 2).

Table 2. Bodyweight and body size parameters of major gene carriers in the Nigerian local chicken

Measurement	Naked neck	Frizzle	Polydactyly	Ptylopody	Normal
Bodyweight, kg	1.2	1.3	1.5	1.3	1.3

Body length, cm	36.7	37.6	40.4	39.8	39.2
Body girth, cm	26.9	26.7	28.4	27.3	27.5
Shank length, cm	9.7	10.2	10.4	9.7	9.7
Wing length, cm	17.5	17.8	18.3	18.1	17.7
Toe length, cm	4.7	4.8	4.9	4.9	4.8
Shankdiameter, mm	13.4	13.6	14.4	14.3	13.5
Keel length, cm	0.2	0.3	0.3	0.3	0.3

Polydactyl birds were superior to ptylopod birds and their respective recessive gene carriers in body weight, body length, keel length, wing length, toe length and shank diameter. The recessive gene carriers for feather distribution and feather structure genes (i.e. nana and ff) were higher in body length, body girth and shank diameter than their respective dominant gene carriers (i.e. naked neck and frizzle birds). Frizzle birds were also superior to naked neck birds in all the body size parameters except for body length and body girth. The observed superiorities were however not statistically significant (Table 2).

Genetic effect of the dominant alleles were generally low in the present study especially for body weight, wing length and shank diameter (Table 3) the genetic effect of the naked neck alleles (Na) were negative for body weight and body size parameters, while the genetic effect of the other three dominant alleles (F, Po, and Fsh) were positive for most of the measured traits (Table 3).

Table 3. Effect of genotype on bodyweight and body size parameters

Measurement	Naked neck	Frizzle	Polydactyly	Ptylopody	Normal
Bodyweight, kg	-0.04	+0.00	+0.03	+0.03	-0.07
Body length, cm	-1.31	+0.38	+0.13	+0.13	-0.52
Body girth, cm	-0.67	-0.47	+0.86	-0.54	-0.32
Shank length, cm	-0.23	+0.30	+0.09	+0.02	-0.11
Wing length, cm	-0.14	+0.13	+0.13	-0.11	-0.02
Toe length, cm	-0.55	-0.43	-0.18	-0.01	+0.19
Shank diameter ,mm	-0.18	+0.05	+0.01	-0.05	-0.06
Keel length, cm	-0.04	+0.02	+0.31	+0.31	-0.71

The allele for polydactyly (Po) had a higher positive effect on body girth and keel length than the allele for ptylopody (Fsh) and frizzle feather (F). Mean values for body size parameters in adult male and female birds are presented in Table 4.

Table 4. Mean bodyweight and body size parameters of male and female Nigerian local Chickens

Measurement	Male	Female
Bodyweight, kg	1.4 9 ± 0.43[a]	1.13 ± 0.29 [a]
Body length, cm	41.96 ± 4.60 [a]	37.22 ± 3.44 [a]
Body girth, cm	28.83 ± 3.35 [a]	26.49 ± 2.09 [a]
Shank length, cm	10.79 ± 1.23[a]	8.90 ± 1.13[b]
Wing length, cm	18.80 ± 2.85 [a]	16.79 ± 2.75 [a]
Toe length, cm	5.23 ± 0.76 [a]	4.49 ± 0.57 [a]
Shank diameter, mm	0.38 ± 0.20 [a]	0.20 ± 0.12 [a]
Keel length, cm	14.54 ± 2.20 [a]	12.82 ± 1.80 [a]

[ab] means in the same row for each parameter with different superscripts are significantly different (P <0.05)

Males have significantly (P<0.05) longer shank length than females. The higher values observed in males for body weight, body length, body girth, keel length, shank diameter, wing length and toe length were however statistically significant (p>0.05). The genetic effects of sex on the body weight and body size parameters were about the same in both sexes, except that the values for the females were negative (Table 5).

Table 5. Genetic effect of sex on body size parameters

Body size parameters	Male	Female
Bodyweight, kg	+0.15	-0.15
Body length, cm	+1.73	-1.72
Body girth, cm	+1.05	-1.05
Shank length, cm	+0.55	-0.78
Wing length, cm	+0.93	-0.92
Toe length, cm	+0.82	-0.83
Shank diameter, mm	+0.36	-0.36
Keel length, cm	+0.05	-0.05

The present result on the frequencies of naked neck and frizzle allele, agreed with the submission of Sonaiya and Olori (1990) who reported low frequencies of occurrence for naked neck and frizzle among surveyed birds in South-Western Nigeria. The low frequencies for the dominant alleles in the present work suggest that these alleles are probably under a negative selection process. Earlier studies by Akinokun (1990) and Ikeobi et al (1997) showed gene frequency of 10 percent and 8 percent (respectively) for polydactyly in Nigerian local chicken. The present frequencies (2 to 3 percent) for the dominant alleles suggest that birds that are dominant gene carriers for the investigated major traits are at the brink of extinction. It also showed a dwindling prospect for the use of these dominant alleles in future livestock improvement programmes.

More recently, Sonaiya (2003) observed that both naked neck and frizzled birds are becoming threatened collections. Interaction with local poultry keeper during the present study revealed that a lot of social and traditional values are placed on the investigated dominant gene carriers due to the important roles they play in rituals and sacrifices. In some places, social bias has led to the elimination of birds with ptylopody. Ikeobi et al (1997) postulated that the low frequency of ptylopody to be due to the combined effect of social preference, natural selections and adaptation. Earlier, Sonaiya and Olori (1990) had reported that farmers see frizzled and naked neck birds as ugly and irritating and that naked neck birds are to be raised only by old people and for occult purposes.

Average body weights of adult birds in this study were in agreement with earlier reports (Nwosu and Asuquo 1985; Nwosu and Onseje 1985; Oluyemi and Roberts 2000) that indigenous chickens are relatively small in body weight. The present work supported the earlier submission of Shoffner et al (1993) that the dominant marker stock with reported gene for polydactyly and ptylopody were insignificantly higher in body weight when compared with their recessive counterparts at 32 weeks of age. The significant superiority of polydactyl birds above the recessive gene carrier (four toe birds) in girth weight and shank length and its superiority in most other traits suggest its potential for meatiness. The present result run contrast to earlier submissions (Horst 1988; Marthur and Horst 1990; Eberhart and Washburn 1993) that individuals with frizzle and naked neck genes both singly and in combination were superior to their recessive gene carriers. The difference may be due to the small body weight and body size of Nigerian local chicken. According to Abdul-Rahman (1989) body weight and body size play a vital role in adaptability. A later work by Eberhart and Washburn (1993) showed that naked neck gene failed to confer resistance to chronic heat stress in small body weight populations. According to Chahaner et al (1992, 1993) naked neck gene is not only influenced by temperature condition, it is also influenced by the rate of growth of birds used in the study. The effect of naked neck gene in reducing heat stress is greatest in more rapidly growing stocks than in slow-growing stocks. Gowe and Fairfull (1995) reported that small body weight birds showed a smaller change in body temperature when exposed to acute heat than larger body weight birds. It therefore seems that all the investigated birds because of their small body weight and size have adjust so well that they are not under thermal straps.

The higher proportion of adult females in this work is in line with what is expected in a natural breeding flock. Moreover, there is the social factor that allows the best animals - usually males - to be preferentially selected for culling during festivity periods. Average bodyweight of male and female birds falls within the range reported by Hill (1954). The present report tended to support the work of Prado - Gonzalez et al (2003) in native Creole chicken from South-Eastern Mexico that males were generally heavier than females. The higher shank length reaches the maximum in females earlier than in males. Okpeku et al (2003) reported that shank length was higher in male than in female adult chicken.

Conclusions

- It may be concluded that the potentials of thermoregulatory feather genes (Na and F) to improve bodyweight and body size parameters may not be realized in Nigerian local

chickens via direct selection because of their generally low bodyweight. It is therefore recommended that dominant gene carriers for naked neck and frizzle be used in cross breeding with exotic birds with a view to enhance their adaptability to the humid tropical production environment.

- Managements of birds in a controlled environment may help to further prove the superiority of polydactyl and ptylopod birds. There is also the need to stem the negative selection against the dominant alleles through village level extension services.

References

Abdul- Rahman A E 1989 Significance of some major genes in relation to the productive adaptability of four German sublines compared with local Egyptian chickens under Assiut subtropical conditions. Dissertation, Assiut University, Egypt.

Akinokun O 1990 An evaluation of exotic and indigeneous chickens as genetic materials for development of rural poultry production in African in :Rural poultry in Africa. Sonaiya E B (Editor). Proceedings of an international conference on rural poultry production. Thelia Honse, OAU, Ile-Ife, pg. 56.

Chahaner A, Deeb N and Gutman M 1992 Improving broilers growth at high temperature by the naked neck gene. Proceedings of XIX World's poultry congress, Amsterdam. The Netherlands, Volume 21. Pp 57-60.

Chahaner A, Deeb N and Gutman M 1993 Effect of the plumage reducing naked neck (Na) gene in the performance of fast growing broilers at normal and high temperature. Poultry Science 72:767-775.

Duncan D B 1955 Multiple range and multiple f test. Biometrics 11: 1-42.

Eberhart D E and Washburn W 1993 Assessing the effect of the naked neck gene on chronic heat stress resistance in two genetic populations. Poultry Science 72: 1391 - 1399.

Gowe R S and Fairfull R W 1995 Breeding for Resistance to heat stress in: Poultry production in hot climates M J Daghis pub-cab International, Wallingford Oxon.

Haaren-Kiso A, Horst P and Zarate A V 1995 Direct and indirect effects of the frizzle gene (F) on the productive adaptability of laying hens. Animal Research and Development. 42: 98-114.

Hill D H 1954 Poultry production in Nigeria. Section paper. 10th World poultry congress (Edinburgh) 1954: 318 - 321.

Horst P 1988 Native pool as resources for genome and major gene with direct and indirect effect on productive adaptability. Proceedings XVIII World poultry congress, Nagoya, Japan.

Ibe S H 1993 Growth performance of normal, frizzle and naked neck chickens in a tropical environment. Nigerian Journal of Animal Production. 20:25 - 31.

Ikeobi C O N, Ozoje M O, Adebanbo O A and Adenowo T A 1997 Frequencies of feet feathering and comb type genes in the Nigerian local chickens. Paper presented at the workshop on African Network for rural poultry development, M'Bour, Sénégal, December 1997, 8 pages.

Ikeobi C O N, Adebambo O A and Adenowo T A 1998 Distribution of the ptylopody gene in the local pigeon. Nigerian Journal of Genetics. XIII: 58-60.

Marthur P K and Horst P 1990 Single and combined effects of tropically relevant major genes on performance of layers. Proceedings, 4th World Congress on Genetics applied to livestock production. Edinburgh XVI: 65-68.

Nwosu C C and Asuquo B O 1985 Body weight improvement in local chicken Proceedings, 10th Annual conference, Nigerian Society for Animal Production, pp 23-29.

Nwosu C C and Omeje S S 1985 Improved annual egg production from Nigerian local chicken by Gold link cross progeny. Nigerian Journal Animal Production 12:161-164.

Oluyemi J A and Roberts F A 2000 Poultry production in warm wet climate. Spectrum Books Ltd, Ibadan, Nigeria.

Okpeku M, Orheruata M and Imumorin 2003 Phenotypic genetic variation among local chickens in Edo State of Nigeria. Proceedings, 28th Annual conference, Nigerian Journal of Animal Production, Volume 28:119-121.

Pisenti M E, Delany R L, Taylor (Jr) U K, Abbott R, Abplanalp H, Arthur J A, Bakst M R, Baxter-Jones C, Bitgood J J, Bradley F A, Cheng K M, Dietert R R, Jodgson J B, Donoghue A M, Emsley A B, Etches R J, Frahm R R, Gerrits R J, Goetink P F, Grunder A A, Harry J E, Lamont S J, Martin G R, Mc-Guire P E, Moberg G P, Pierro L J, Qualset C O, Qureshi M A, Shultz F I and Wilson B W 1999 Excerpt from Avian Genetic Resources at Risk. An assessment and proposal for conservation of genetic stocks in the U.S.A. and Canada. Report No. 20. University of California Division of Agriculture and Natural Resources. Genetic Resources Conservation Programme. Da C.A. USA, 120 pages.

Prado-Gonzalez E A, Ramírez -Avila L and Segura-Correa C 2003 Genetic parameters for body weights of Creole chickens from SouthEastern Mexico using an animal model. Livestock Resources for Development 15(1):

Shoffner R N, Otis J S and Garwood V A 1993 Association of dominant marker traits and metric traits in chickens. Poultry Science 72: 1405-1410.

Sonaiya E B 2003 Producing local livestock- improving rural livelihoods. Proceedings of the 28th Annual conference of the Nigerian Society for Animal Production, Volume 28: 462.

Sonaiya E B and Olori V E 1990 Village chicken production in South-Western Nigeria. In: Rural Poultry in Africa. Sonaiya E B (editor). Proceedings of an international conference on rural poultry production. Thelia House, O.A.U., Ile-Ife. Pages 243-247.

Steel R G D and Torrie J H 1980 Principles and procedures of statistics. A biometrical approach. 2nd edition, Mc Graw-Hill Book By. Inc. NY.

Washburn K W, Peavey R and Renwick G M 1980 Relationship of strains: Variation in blood pressure and response to heat stress. Poultry Science 59:2586.

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