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PRESENCE OF THE POLYDACTYLY GENE IN THE NIGERIAN LOCAL CHICKEN

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Target audience: Research scientists, conservationists, breeder managers.

ABSTRACT

An investigation was carried out to determine the percent incidence of the polydactylous condition and the frequencies of the genes, Po and po, in this condition in the mature Nigerian local chicken reared in south-western Nigeria. A total of 2018 adult local chickens of both sexes managed under the predominant scavenging system were surveyed and only nine were polydactylous. The penetrance of the polydactylous condition was generally low (0.446 %) in south-western Nigeria, giving rise to a frequency of 0.002 for the dominant allele, Po, inluencing the condition. Frequency of the recessive allele, po, was 0.998 and these values were significantly different from expected values. This coul possibly be due to the role of natural selection and social preference among the populace operating against birds manifesting the character. The average length of the extra digit was 2.17 cm and was longer in males (2.50 cm) than in females (1.90 cm). The effect of the incidence of the condition was significant ($P < 0.05$) for only wing length and breast girth, favouring mature birds with the 'normal' four toes. Wing lengths averaged 16.25 cm and 13.88 cm for the non-dactylous birds and the polydactylous birds respectively, while breast circumference averaged 27.20 cm and 25.85 cm for the two groups respectively. These values differed significantly from one another and they provide further justification for the apparent social preference against polydactylous local chickens of south-western Nigeria.

Key words: Polydactyly; genes; local chicken.

DESCRIPTION OF PROBLEM

The Nigerian local chickens have been presumed to be reservoirs of rare genes. Some of these genes have been shown to be tropically relevant, important in the survival, growth and reproduction of the breed especially under the prevailing scavenging system of managing the breed in its hot humid native environment. These are genes for frizzled feathers, naked neck and sex-linked dwarfism (1, 2, 3, 4). The frequencies of these genes have been reported to be low (3), indicating that they are rare, even though some of the genes are dominant. This implies that there are possible social

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pr rence or unsystematized artificial selection against the genes in the population (5). Some of the genes are modifiers, the effects of which are still manifested in the performance of the breed (5, 6). Comprehensive genetic characterisation of the Nigerian local chicken is useful for the conservation and improvement of the breed in its native environment (7). In characterising the Nigerian local chicken, the appendages, especially the shanks and the wings, deserve special consideration in view of their specific roles in fight, flight and feeding in the flighty and highly temperamental, predominantly-scavenging rural poultry. Polydactyly, a condition of more than four toes in a shank of the bird, has been observed in the breed (7) but their effects on the breed have not been reported. Working in south-eastern Nigeria, Nwosu et al. (7) found only one chicken with five digits in each foot. This condition is influenced by a single, autosomal dominant gene, Po (8, 9). Hutt (8) observed that the extra digit of the polydactylous chickens arises from the metatarsus of the first toe on the inner side of the foot. The present study was therefore undertaken to characterise this condition, estimate the frequencies of the genes controlling it and to determine the effects of these genes on the adult body weight and some linear body measurements of the Nigerian rural poultry species.

MATERIALS AND METHODS

A study spread over two years was conducted and it involved the survey of 2018 adult local chickens reared in some villages around the south-western cities of Sagamu, Ikenne, Abeokuta, Odeda and Otta. The existence of a distinct ecotype of the local chicken around Sagamu has been reported (10, 11) and it is in this area that the study was undertaken. This locality is commonly marked by high humidity usually caused by high, bi-modal annual rainfall and high temperature which reaches a maximum of 35 ^{o}C for a typical February day (12).

This climatic situation provides a great deal of thermal stress which impacts greatly on animals exposed to extremes of weather conditions in the hot humid tropical environment (13). Both sexes were surveyed at maturity, because the development and growth of the extra toes, where they occur, would have been maximum in that age group. Birds were grouped as either polydacty or non-polydactylous and possible association of that condition v e presence of major genetic effects of frizzling, naked neck, sex-linked dwarfism and ptilopody was investigated. Frequencies of both the dominant (Po) and the recessive (po) genes involved in the polydactyly were estimated from maximum likelihood methods (14) and tested against expected values using chi-square test (15).

The liveweight of the birds were recorded coupled with the linear body measurements which included comb height, comb length, shank length, body length, wing length, breast circumference, beak length and standing bird height. Details of how these measurements were taken were as provided by Ikeobi et al. (3) and Ayorinde (16).

A linear model for analysing the effect of the incidence of polydactyly was assumed with the incidence of polydactyly as the main effect using Harvey's (17) programme. Preliminary analyses involved the inclusion of the interaction of sex and incidence of polydactyly in the model as an additional variable but this was not important and so was later excluded from the final model which was as follows:

$$Y_{ijk} = \mu + P_i + S_j + E_{ijk}$$

where Y_{ijk} = observed values of body weight or linear body measurement.
μ = population mean
P_i = effect of the ith incidence of polydactyly (i= absent, present)
S_j = effect of jth sex (j= male, female)
E_{ijk} = random residual with zero mean and variance $\delta^2 e$

RESULTS AND DISCUSSION

Gene frequencies : Of the 2018 adult local chickens, made up of 1266 cocks and 752 hens, only nine of them, four cocks and five hens, were polydactylous, manifesting the condition as a duplication, more or less, of the first digit. This represents 0.446 % of the total number of the adult local chickens surveyed. Since the gene, Po, controlling the polydactylous condition is a single, autosomal and dominant one (8, 9), the frequency of this gene was estimated from maximum likelihood methods to be 0.002, while that of its recessive allele, po, responsible for the four toes on a shank was estimated to be 0.998 (Table 1).

Table 1: Frequencies of the polydactyly genes in the Nigerian local chicken.

Character	Number of Observations	% Incidence	Gene Frequency
Polydactylous chickens	9	0.446	Po = 0.002
Non-polydactylous chickens	2009	99.554	po =0.998
Total	2018	100.00	1.000

These estimates were found to be significantly ($P < 0.05$) different from the expected Mendelian ratios of 0.50 and 0.50 respectively. These variations may be due to the possible greater influence of natural selection rather than social preference since natural selection is unlikely to greatly alter genetic equilibrium. Since the polydactylous gene, Po, is dominant, it is to

be expected that the gene will be highly prevalent in the population. However, some drastic natural selection might have occurred, thereby stabilising non-polydactyly as the norm that is socially acceptable (13). This is more plausible since it is not known that any formal systematised selection against the polydactylous condition has been carried out on the Nigerian local chicken in the past. It is therefore plausible that a further action of social preference has impacted on the manifestation of this character in the local chicken of south-western Nigeria. In the studies on the genetic characterisation of the Nigerian local chicken to date, this character is the first to be highlighted as experiencing the highest level of reduction in overall expected expressivity rating in the breed and in the local environment (3, 5, 6, 18, 19). This represents a very high level of genetic erosion in the breed. For a breed with a highly flighty and temperamental disposition, the presence of an extra toe woul be expected to be of great benefit in its scavenging, scratching, fighting, feed sourcing and body care behaviours in its native hot humid habitat.

Table 2 shows the unique characteristics of the adult local chickens that showed the polydactylous condition. All the polydactylous birds had the single comb type, smooth feathers (without frizzled feathers and naked neck condition) and smooth feet (absence of feathered feet, a condition known as ptilopody). This indicates that polydactyly is not associated with the incidence of ptilopody and the presence of frizzling and naked neck genes in the adult forms of the Nigerian local chicken. It is also an

Table 2: Some physical features of the polydactylous adult local chicken

Sex	Feather Condition	Feet Condition	Comb Type	Body Weight,kg	Shank Length,cm	Extra toe length, cm
Female	Full, smooth	Smooth	Single	0.90	8.0	2.0
Female	Full, smooth	Smooth	Single	0.60	7.0	1.5
Female	Full, smooth	Smooth	Single	0.50	8.0	2.0
Female	Full, smooth	Smooth	Single	0.60	7.0	2.0
Female	Full, smooth	Smooth	Single	0,70	7.0	2.0
Male	Full, smooth	Smooth	Single	0.60	9.0	3.5
Male	Full, smooth	Smooth	Single	0.60	9.0	2.0
Male	Full, smooth	Smooth	Single	0.60	9.0	2.5
Male	Full, smooth	Smooth	Single	0.90	9.0	2.0

indication that these genes suppress the polydactylous condition in the adult stage of the species. Stevens (9) reported an association of polydactyly with ptilopody and syndactyly (a condition in which some toes of the chicken are mutually webbed together) but noted that the chicks that were so affected died within three weeks of hatching. This morbidity problem was not confirmed by the present study since this study focussed on the adult local chickens. However, it is possible that all such local chicks that

did exhibit such multiple traits were eliminated at the juvenile stage of life.

The length of the extra shank digit in the nine birds that had it ranged from 1.50 to 3.40 cm, with a mean length of 2.17 cm. Six of the nine adult birds, four hens and two cocks, had a length of 2.00 cm for the extra digit. Body weights of the polydactylous chickens were also variable and had a negative correlation (r = - 0.158) with the length of the duplicate toe. Sex dimorphisms in body weight for the polydactylous birds were not apparent. In this study, polydactylous cocks averaged 0.675 kg in weight while the polydactylous hens had a mean live weight of 0.66 kg. This was inspite of the significant sex dimorphisms earlier reported for the local chickens for body weight and some body dimensions (3) and which were confirmed by this study (Tables 3 and 4). The negative correlation between body weight and the length of the extra digit in polydactylous chickens would indicate that there is an inverse relationship between the live weight of the local chicken and the length of the extra digit, increasing extra toe length leading to a lower body weight of the polydactylous chicken. Also in the present study, the length of the extra digit was found to be positively and significantly ($P < 0.05$) associated ($r = 0.562$) with shank length, the duplicate toe length increasing as shank length increased. Sex dimorphisms were discernible from the values obtained in this study for the shank length of the polydactylous birds and also for the length of the extra digit itself. Average lengths of the extra digit were 2.50 and 1.90 cm for the local cock and the local hen respectively. This confirms earlier reports (8, 9) that the polydactyly gene is autosomal and has an irregular penetrance and expressivity within the population. It also shows that the condition is manifested in both sexes of the local chicken of south-western Nigeria.

Table 3: Mean squares of analyses of variance in the performance of the local chicken

Traits	Sex	Incidence of Polydactyly	Error
d.f	1	1	2015
Comb length	8323.23***	1.91	1.97
Comb height	2545.86***	0.84	1.73
Wing length	1838.16***	50.19**	3.93
Break length	6.36	0.14	1.74
Breast girth	2284.81***	31.08*	6.76
Body length	2564.96***	14.26	4.72
Bird height	3180.80***	4.94	3.34
Body weight	14.67***	0.0001	0.33

Values are Significant: *(P <0.05), **(P<0.01) and ***(P<0.001)
d.f.: Degrees of freedom

Table 4: Performance of local chickens as affected by sex and incidence of polydactyly

Traits	Sex		Incidence of Polydactyly	
	Local Cock	Local Hen	Presence	Absence
Comb length, cm	5.42 ± 0.48[a]	1.21 ± 0.48[b]	3.54 ± 0.63	3.08 ± 0.42
Comb height, cm	2.86 ± 0.45[a]	0.53 ± 0.45[b]	1.85 ± 0.59	1.54 ± 0.40
Wing length, cm	16.06 ± 0.68[a]	14.08 ± 0.68[b]	13.88 ± 0.89[b]	16.25 ± 0.60[a]
Beak length,cm	2.90 ± 0.45	2.82 ± 0.89[b]	2.82 ± 0.59	2.94 ± 0.40
Breast girth,cm	27.88 ± 0.90[a]	25.68 ± 0.89[b]	25.85 ± 1.17[b]	27.72 ± 0.78[a]
Body length, cm	25.70 ± 0.75[b]	23.36 ± 0.75	25.16 ± 0.97	23. 90 ± 0.65
Bird height, cm	25.11 ± 0.63[a]	22.51 ± 0.63[b]	24.18 ± 0.82	23.44 ± 0.55
Body weight, kg	0.73 ± 0.20	0.55 ± 0.20[b]	0.67 ± 0.26	0.64 ± 0.17

Means in the row within variable set bearing different superscripts differ significantly ($P<0.05$)

Effects on performance: The least-squares analyses of variance of the live weight and body dimensions of the local chicken as affected by the incidence of polydactyly are shown in Table 3. Incidence of polydactyly significantly affected wing length ($P < 0.01$) and breast circumference ($P < 0.05$), but its effects were not significant for comb length, comb height, beak length, bird height and live body weight of chicken. The corresponding least-square means are shown in Table 4. The local chickens with four toes had significantly longer wings and significantly larger breasts compared to those with extra digits. Average wing lengths were 16.25 and 13.88 cm for the two groups respectively. Corresponding values for breast girth or circumference were 27.20 and 25.85 cm respectively. The significantly shorter wing for the polydactylous birds may be due to the presence of a small rudimentary digit on the anterior edge of the wings of only the polydactylous chickens which may persist throughout the life of the chicken. Since the avian wings represent the "forelimbs" of the species, this extra digit in the wing is also seen as an extra indication of polydactyly in the birds having the Po gene. Baumann and Landauer (20) and Landauer (21) reported on this development and related it to homozygosity of the Po gene in the chicken. It is not yet clear whether the presence of this extra digit on the wings of the local chicken would enhance or suppress flight in the species thereby promoting or limiting adaptation and survival of the species in the natural hot humid environment.

The significantly larger breasts obtained for the non-polydactylous local chicken relative to the polydactylous ones would mean that polydactyly is associated with reduced muscling and meatiness in the species since breast size has been reported to be a good indicator of meatiness in most poultry species (22, 23). Perhaps, from economic standpoint, this would justify the apparent social preference for the non-polydactylous chicken over the polydactylous ones.

CONCLUSION AND APPLICATIONS

This study lends scientific basis and support to the preference against polydactylous birds as the condition was found to have significantly ($P < 0.01$) depressed performance in the adult chicken in terms of live weight and linear body measurements. The only probable advantages of the duplicate digit on the bird's foot is increased effectiveness in scratching for feed under the scavenging system of management. However, if sound management is adopted, including housing and ad libitum provision of nutritive feeds, this probable advantage of the extra digit may not even be realised. This study elucidates on the degree of variability in aspects of both the quantitative and qualitative characteristics of the local chicken of south-western Nigeria.

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