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OCCURRING PATTERNS AND FREQUENCIES OF COLOUR GENES IN SOME INDIGENOUS POULTRY SPECIES IN NIGERIA

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Target Audience: Animal /poultry breeders, breeding farms, quantitative geneticists

ABSTRACT

Variation in the colours observed on the shank, plumage, beak and ear lobe of four local poultry species surveyed in South Western Nigeria were studied . In the guinea fowl, four colour types were identified on the plumage (pearl, black, white and ash /gray), three on the shank (yellow, white and black) and three on the beak (black white and black/white combination). On the plumage, three colour genes were identified each responsible for black, white and pearl colour production. The gene frequencies of each of these alleles were also calculated. Plumage colours in local ducks were assumed to be controlled by two segregating alleles co-dominant in relationship. Their observed gene frequencies were 0.5 respectively. On the shank, two segregating alleles were identified, each producing either black or white/ yellow colours. The alleles producing black were found to be completely dominant to that producing white. Similar colours observed in the beak were co-dominant in action. In pigeon, gray, black, white and white mixed black and white plumage colours were observed. Black and white colours were produced by two segregating alleles co-dominant in action. On the shank, red colour was completely dominant to black, each having a gene frequency of 0.62 and 0.38 respectively. Three alleles segregating on the beak producing black, white and spotted black colours respectively. In turkeys, black plumage colour was more frequent followed by white and brown. The gene frequencies of black, white and brown colours were 0.33, 0.21 and 0.36 respectively, while the gene frequencies of black and white/yellow shank colours were 0.53 and 0.47 respectively. Black was completely dominant to white . On the beak, similar results were observed. Ear lobe colours observed were red and white. Red appeared dominant to white occurring at a measurable ratio of 2.2:1. The gene frequency of red ear lobe allele was estimated as 0.44 and 0.56 for white ear lobe allele. Gene frequencies and inheritance pattern are useful in selection, especially in the development of trade mark or breed identity.

Key words: Colour, genes, frequencies, plumage, shank, beak, poultry.

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DESCRIPTION OF PROBLEM

Colour is inherited almost entirely through the segregation of major genes. It is a highly repeatable trait (1,2). One of the functions of colour is communication either in mating desires or in warning signals to other animals. Colour also function as a concealment and so is found to be very important in adaptation (2) According to Hutt (3), colour plays an important role in the productivity of the domestic fowl, yellow beak and shank being indicative of poor laying charateristics

Considerable variation occurs in the composition of colour either on the plumage or on the shank, beak and ear lobe of various poultry species in Nigeria. This multi colour variation is as a result of lack of selection or breeding programmes directed towards choice of colour (4). Corroborating this view, Odubote (5) stated that large variation in colour is indicative of a traditional population where no conscious selection effort has been practised.

Although, the importance of the variation in the colour of plumage, shank, beak and ear lobe of these species is not clearly understood, the distribution pattern and frequencies of occurrence of these varying colours appear to show that some are more prominent and probably more important than others in adaptation and survival. Nevertheless, this paper is aimed at studying the pattern of occurrence and gene frequencies of the colour types on the plumage, shank, beak, and ear lobe of some poultry species such as duck, pigeon, guinea fowl and turkey in South Western Nigeria.

MATERIALS AND METHODS

Colour varieties on the shanks, beaks ear lobes and plumage of four local poultry species (turkey, guinea fowl, pigeon and duck) surveyed in the eight states of South Western Nigeria were studied.

The 1171 birds involved in the study were managed exensively with shelter being provided for sleeping and protection against inclement weather. Mobility is a common feature in the management system as birds are allowed to freely roam around feeding on pastures, kitchen wastes and crop residues with little or no control. As they moved from place to place, they were prevented from exposure to high concentration of pathogens in their droppings and the overgrazing of pasture land. However, extensive system exposes birds to the extremes of weather conditions (6,7). Types, frequencies of occurrence and distribution pattern of these colours were studied alongside their gene frequencies.

Analytical Procedures

Patterns of inheritance were fitted for the colour types based on the ratios and frequencies of occurrence. The observed ratios were tested against the expected using the simple Chi-square test procedure (8). The estimation of gene frequencies at the various colour loci was based on the tested assumptions that two or three alleles are segregating at each locus and these alleles could

either be expressed in complete dominant, co-dominant or incomplete dominant forms based on the pattern of occurrence. Estimates of allelic frequencies were calculated by the Hardy-Weinberg equilibrium and the maximum likelihood methods (9, 10). The observed gene frequencies were tested against the expected for goodness of fit using the Chi-square test procedure.

RESULTS AND DISCUSSION

Guinea fowl

Colour variations were observed on the plumage, beak and shank of guinea fowl birds surveyed. Colour varieties observed on the plumage of these birds are ash/gray, black, white and pearl as shown in Table 1. Smililar observations were reported by Ayorinde (11). The occurring pattern of these colours showed that black and pearl were the most common, representing 40.66 and 42.64 percent respectively of plumage colour in the total number of guinea fowl birds surveyed (Table 2). White and ash/gray colour birds represented 11.43 and 5.27 percent respectively. Although Ayorinde (11) reported that white was the rarest plumage colour in guinea fowl, the result of this study revealed that ash coloured birds were the least common. Ayorinde's report is likely to have been largely affected by location which included Ilorin and its environs. The distribution pattern of these colour types in our survey showed that ash coloured birds were concentrated in Kwara State area which included the area where Ayorinde's study was conducted. Black and pearl coloured birds were widely distributed throughout the areas surveyed.

Table 1. Colour observed among the species of poultry surveyed.

Variabies	Guinea fowl	Duck	Pigeon	Turkey
Plumage	Black	Black	Black	Black
	Pearl	White	White	Ash (gray)
	Ash (Lavendar)	Black/white	Ash "(gray)	White
	White		Black/white	Brown
Shank	Black	Black	Black	Black
	White	White	Red	White
	Yellow	Yellow	Ash (gray)	Yellow
Beak	Black	Black	Black	Black
	White	White	White	White
	Spotted Black (piebald)	Spotted Black (piebald)	Ash (gray) Spotted Black (piebald)	Yellow
Ear lobe	White	--	--	White Red

The observed ratio of occurrence among these colour types tended to reveal complete dominance and co-dominance inheritance pattern (Table 2). Three alleles appeared to be segregating at the plumage colour locus. These are

genes responsible for black, pearl and white plumage colours represented by A, A^h and a respectively. a is completely recessive to both A and A^h, while A and A^h are expectedly co-dominant in action. This was confirmed by the observation of birds with combination of black and pearl plumage colours in the cause of this study. Chi-square test confirms that the observed ratios fitted the expected. Gene frequencies on the basis of these ratios in inheritance pattern are shown in Table 2. The frequency of the a allele was 0.34, while that of the A allele was 0.27. The Frequency of Ah allele was 0.28. Similar gene frequency pattern was reported in Faeroe Island sheep (9). About 31 percent of the population of the birds studied were carriers of the white plumage colour gene, while 25 and 26 percent respectively were carriers of the gene responsible for black and pearl plumage colours. Ash/gray colour may have appeared in the guinea fowl birds because of the influence of a modifier gene. The modifier gene is located on the colour intensity locus and is respondible for the modification/dilution of colours produced at the agouti and solid colour loci. In double recessive form, the modifier gene induces an epistatic effect, modifying the effect black in this case to ash/gray. The frequency of the modifier allele (m) was estimated as 0.23 (Table 2).

Table 2: **Pattern of occurrence and frequencies of colour genes observed in the local guinea fowl birds surveyed.**

Varieties	Number of Observations	Freq.of Occurrence (%)	Gene frequency	
Plumage			**Observed**	**Expected**
Black	278	40.66		
Pearl	291	42.64	A=0.27	A=0.43
Ash (lavender)	36	5.27	A^h=0.28	AL=0.44
White	78	11.43	a=0.34	a=0.12.
Shank				
Black	405	59.34	B=0.36	B =0.5
White	185	27.03	b = 0.64	b =0.5
Yellow	93	13.63		
Beak				
Black	172	25.06	B = 0.40	B =0.5
White	262	38.40	b =0.60	b= 0.5
Spotted black (piebald)	249	36.48	S = 0.25 s = 0.75	S = 0.5 s = 0.5

Although the presence of light brown and gray colour shanks in the guinea fowl had been reported (11), the shank colours observed in this study were white, yellow and black. Similarly, the colours obsetved on the beak (black,white,and spotted black)were different from those reported by Ayorinde (11). Black shank and beak are the result of the presence of melanin in the epidermis and dermis of the shank and beak of birds (3). The blackest shank and beak have dense deposition of melanin on the dermis as well as the epidermis. Birds with yellow or white shank and beak lack melanin in the

dermis because they carry genes preventing the deposition of melanin there. Melanin on the dermis is caused by a sex linked recessive allele (id) in either homozygous or hemizygous conditions. Yellow colour according to Hutt(3) is not produced by the cells of the fowl as in melanin. Yellow colour depends upon the presence of carotene and xanthophyll. North (12) found that yellow colour on bodies of birds correlates with the amount of xanthophyll in the ration. Continous laying birds loose yellow pigment on the skin, beaks and shanks (3). Consequently, the good layers can be distinguished from poor layers with a high degree of accuracy by estimating the degree of pigmentation. However, Card and Nesheim (13) reported similar results stating that yellow colour reappears in the same order in which it disappeared when laying stops, thus, indicating that a genetic basis exists for the deposition of the yellow colour obtained from the carotenoid pigment in the epidermal layers of either the shank or the beak. The absence of carotenoid pigments prevent the deposition of yellow pigment either on the shank or on the beak. Based on the ratio of occurrence observed in the extensively managed birds in this study, it is assumed that the gene allowing or preventing the deposition of the yellow pigment on the epidermis occurs on a gene locus interacting with the shank colour locus/loci. In homozygous and heterozygous dominant form, it prevents the deposition of the yellow pigment on the epidermis, but allows the deposition of the yellow carotenoid pigement in completely recessive form. This could be confirmed by the observed ratio of yellow to white. The frequencies and percentage occurrence of colour types on the shanks of guinea fowl birds surveyed showed that 59.34 percent of the total birds population had black shanks, while 27.03 percent had white shanks. Similarly 13.63 percent of the sampled population had yellow shanks (Table 2). All the colour types except yellow were evenly distributed in the geographical areas surveyed. Yellow shank guinea fowls were concentrated in Ogun and Oyo States. From the relative frequency estimates (Table 2) and occurrence ratio, black shank colour genes appeared completely dominant to both white and yellow shank colours. The observed ratio was not significantly different from the expected ratio ($X^2 > 0.05$). The estimated gene frequency for yellow/white shank represented by the allele b was 0.64, while that of the black shank (B) was 0.36. The frequency of the gene allowing for the deposition of yellow pigment on the epidermis was estimated as 0.43 and 0.57 for the gene preventing yellow pigment deposition . The percentage of population carrying the recessive allele that allows the deposition of yellow pigment on the shank was estimated to be 73.5 (q^2 +2pq). Similary 96.4 percent of the population carries the allele preventing the deposition of yellow pigmentation on the shank of the guinea fowl birds (p^2 +2pq) either in homozygous or heterozygous form.

About 25.06 percent of the sampled population had black coloured beak, while 38.40 and 36.48 percent had white and spotted beak respectively. The observed ratio occurrence was approximately 1:1:1. However, the ratio of black to white beak assuming that spotting was imposed by an allele at the S locus was

approximately 2:1 revealing the presence of two segregating allele probably operating in complete dominant recessive form. Chi-square test results ($X^2 > 0.05$) showed that the observed ratio (2:1) fitted the expected (3:1) assuming a complete dominance of black over white. The gene frequencies of the black and white alleles (B and b respectively) were estimated as 0.4 and 0.6 respectively. Thus, about 64 percent of the sample population of guinea fowl birds studied were carriers of the dominant allele for black beak. At the S locus the gene frequency of the spotting gene was estimated to be 0.75 (s).

Local Ducks

Plumage shank and beak colours in the indigenous ducks surveyed in South Western Nigeria revealed that two major colour genes are likely to be controlling colour production on the plumage, shank or beak of these birds. As shown in Tables 1 and 3, plumage colours observed in local ducks : black, white and mixed black and white occurred at an observed ratio of approximately 1:1:2 respectively. Each of these colour types were evenly distributed in the geographical areas covered by the study. The frequenccy of occurrence of these colours revealed that 48.23 % of the sample population had mixed colours of black and white feathers, while 26.35 percent of the sampled population had mixed colours of black and white feathers, while 26.35 and 25.42 percent were covered with complete black and white feathers respectively (Table 3). The observed ratio of occurrence showed that black and white colour genes on the duck plumage are likely to be co-dominantly inherited, suggesting that two alleles (B1 and B2) are likely to be segregating at the plumage colour locus. In homozygous forms, they produce black and white plumage colour respectively, while the heterozygous form results in the production of mixed coloured plumage (black and whilte). Chi-square test revealed non significant difference between the observed and expected ratios. The gene frequencies of these alleles in the sampled population calculated on

Table 3. Pattern of occurrence and frequencies of colour observed in the local duck birds surveyed.

Varieties	Number of Observations	Freq.of Occurrence (%)	Gene frequency	
Plumage			**Observed**	**Expected**
Black	100	26.35		
White	97	25.42	B1 = 0.5	B1 =0.5
Black/white	183	48.23	B 2= 0.5	B2 = 0.5
Shank				
Black	216	56.86	B = 0.38	B = 0.5
White	135	35.44	b = 0.62	b = 0.5
Yellow	29	7.7		
Beak				
Black	162	42.68		S = 0.5
White	01	0.15	S = 0.25	s = 0.5
Spotted black (piebald)	217	57.17	s = 0.75	

the basis of the observed ratio of occurrence and inheritance pattern showed that these alleles in the population of local ducks in South Western Nigeria is 0.05. Similarly the genotypic frequency of the mixed coloured populations was also 0.05, which means that about 75 percent of the population are carriers of the B2 allele.

On the shank, three colours were also observed, that is black, white and yellow (Table 1) . As stated ealier, black results from the influence of melanin deposition on the dermis and epidermis of the shank and is controlled by a sex linked gene, id (3,13). Although yellow shank colour results from the presence of carotene and xanthophyll in feeds, its depostion on the epidermis of the shank has an existing genetic basis controlled by the presence of an allele recessive in expression. Yellow shank birds are assumed to be carriers of the white shank allele that prevents the deposition of melanin on the dermis and epidermis and at the same time carrying the allele permitting the deposition of yellow carotenoid pigment on the epidermis of the shank. The frequency or percentage occurrence of these colours showed that black-shanked birds were most common (56.86 percent), followed by the white shanked birds (35.44 percent) and yellow shanked birds(7.7 percent) in that order (Table 3). Birds with these three colours were found in all geographical zones surveyed. The ratio and pattern of occurrence showed that black shank is completely dominant over the white/yellow shank colour. Two alleles were assumed to be segregating at the shank colour locus, B and b. In both homozygous and heterozygous forms, B results in black shank colour, while bb results in white/yellow shank depending on the presence or absence of the gene that allows the deposition of yellow pigment on the epidermis of the shank. Therefore, the gene frequencies of B and b were estimated as 0.38 and 0.62 respectively. Chi-square test showed no significant differences between the observed and the expected. Expectedly 85.5 percent of the sampled population are carrier of the b allele, while 61.5 percent are carriers of the gene B gene (p2 + 2pq).

The gene allowing or preventing the deposition of carotenoid and xanthophyll pigment on the epidermis of the shank appeared to be located on another locus interacting with the colour locus and at the same time segregating in complete dominant/recessive form (the observed ratio of white to yellow shank was approximately 4:1). The deposition of yellow pigment on the epidermal layer of black shank is obscured by the presence of melanin on the dermis and epidermis (3,13). The frequencies of the genes allowing and preventing the deposition of the yellow colour on the epidermis was estimated on the basis of the observed ratio and found to be 0.53 and 0.47 respectively.

Although, three colour types were observed on the beak of the local ducks in this study, only one white beak duck was seen in the areas surveyed. However, black and spotted white beak were evenly distributed throughout the surveyed areas. The peculiarity of this case led to the assumption that white beak allele may be having lethal/detrimental effect on the survival and subsequent performance of its carrier. Although, black beak allele appeared to be dominant to white

beak based on the frequencies of occurrence, dominance/recessive nature of this gene could only be confirmed from actual experimentation. The estimation of the gene freqencies for beak colour therefore, was not possible because of the lethal nature of the recessive allele. Secondly, the homozygous and heterozygous dominant allele showed the same phenotypic expression. However, the gene frequency of the spotting allele was estimated as 0.25 and 0.75 respectively for S and s.

Local Pigeons

Three hundred and seventy seven (377) pigeons with varying shank, plumage and beak colours were surveyed in the course of this study. Plumage colour varied from black to white, gray and mixture of black and white feathers, while the shank colour varied from black to red and gray. Beak in the indigenous pigeons were either black, white, gray or spotted black or piebald (Table 1). The pattern of occurrence showed that black and white plumage birds were most common followed by white, black and the gray coloured birds (Table 4). Birds with these colour types were found in all the areas surveyed. The frequency of occurrence was 37.13 percent for black and white birds, 28.12 percent for white birds, 19.63 percent for black birds and 15.12 percent for gray pigeon birds. The observed ratio between black and white birds was 1.4:1, which was not significantly different from the expected assuming that black and white colours were co-dominant in action. The gray birds are expected to be carriers of the allele for black plumage colour in addition to a double recessive modifier allele at the pigment intensity locus (14). This double recessive allele acting as an epistatic gene modified black to gray. The frequency of the black and white plumage alleles were estimated as 0.45 and 0.55 respectively, while that of the allele with modifier effect at the locus was estimated as 0.49 (Table 4). The

Table 4: Pattern of occurrence and frequencies of colour genes observed in the local pigeon birds surveyed.

Varieties	Number of Observations	Freq.of Occurrence (%)	Gene frequency	
			Observed	**Expected**
Plumage				
Black	74	19.63		
Ash (gray)	57	28.12	A = 0.45	A =0.5
White	106	15.12	a = 0.55	a = 0.5
Black/white	140	37.13		
Shank				
Red	301	79.84	R = 0.55	R = 0.5
Black	51	13.53	r = 0.45	r = 0.5
Ash (gray)	25	6.63		
Beak				
Black	200	53.05	B = 0.55	B = 0.5
Ash(gray)	13	3.45	b = 0.45	B = 0.5
White	77	20.42	S = 0.52	S = 0.5
Spotted black (piebald)	87	23.08	s = 0.48	S = 0.5

observed frequences were not significantly different from the expected, showing that the observed frequencies fitted the expected. Therefore, the genetic constitution of the pigeon population studied can be said to be appropriately described by the observed gene frequencies and proposed inheritance pattern (11).

A peculiar red colour was obseved on the shank of indigenous pigeon population accounting for about 79.84 percent of shank colours observed in the sampled population. Other colour types observed were black and gray. Percentage incidence of black was 13.53 and 6.63 respectively. The observed ratio of red to black was approximately 6:1, while the black/gray to red was 1:4. The Chi-square test results propose an inheritance pattern where red is completely dominant to black, which means that the homozygous and heterozygous alleles produce red shank phenotype. The black shank alleles appeared to be modified by an allele at the colour intensity locus diluting black to gray in recessive form. The gene frequencies showed that 45.1 percent of the pigeon population studied were heterozygous for the red shank colour.

Beak colour in indigenous pigeon also showed the influence of a modifier gene diluting the black beak colour to gray. Moreso, it followed a particular order operating in recessive inheritance pattern. The frequency of birds with gray beak was 3.45 percent. Other beak colours observed in the cause of this study were black, white and piebald occurring at the relative frequencies of 53.05, 20.42 and 23.08 percent respectively. White was assumed to be controlled by a recessive allele as compared to black. The observed ratio of occurrence was not significantly different from the expected ($X^2 > 0.05$). The gene frequencies of these allele were estimated as 0.55 and 0.45 respectiely for black and white beak colours. Piebald was produced by a recessive epistatic allele at the S locus imposing its pattern on black background. The gene frequency estimated of this allele was 0.48. However, the proportion of the birds carrying this allele (p2 +2pq) is about 80 percent of the total number of bird surveyed. Selection against dominant alleles in a population results in homogeneity in quick successive generations as compared with selection against recessive alleles in completely dominant inheritance traits. The knowledge of inheritance pattern and gene frequencies is therefore useful in breed identity development.

Turkey

Four plumage colours were identified in the course of the study. They are black, brown, ash/gray and white. Although, local turkeys were not seen in all the geographical locations surveyed, the various colour types observed except black were restricted in distribution in the areas where turkeys were found. Turkeys with brown feathers were restricted to the north covering the present Kwara State and Oyo North. Ash/gray coloured birds were found in Lagos and Delta States. The relative frequencies of these colours are presented in Table 5. Ash/gray colour is expectedly a modification or dilution of black influenced by the action of a modifier allele at the pigment intensity

percent. The frequency of the ash allele at the pigment intensity locus was estimated as 0.39 (Table 5).

Table 5 : Pattern of occurrence and frequencies of colour genes observed in the turkey birds surveyed.

Variables	Number of Observations	Freq.of Occurrence (%)	Gene frequency	
Plumage			**Observed**	**Expected**
Black	130	48.00		
Brown	36	13.28	P = 0.46	P = 0.65
Ash (gray)	24	8.89	q = 0.16	q = 0.22
White	81	29.89	r = 0.36	r = 0.13
Shank				
Black	174	64.29	B = 0.48	B= 0.5
White	71	26.19	b = 0.52	b = 0.5
Yellow	26	9.52		
Beak				
Black	174	64.29	B = 0.48	B = 0.5
White	71	26.19	b = 0.52	b = 0.5
Yellow	26	9.52		
Ear lobe				
Red	187	69.05	R = 0.44	R =0.5
White	84	30.93	r = 0.56	r = 0.5

The observed occurrence ratio of black to white (2:1), black and ash to white (2.1:1) when tested with the expected ratio (3:1) agreed with the assumption that black plumage colour is completely dominant to white. Similarly , white also appeared completely dominant to brown with an observed ratio of 2.4:1 ($X^2 > 0.05$). Estimated gene frequencies of the three segregating alleles at the plumage colour locus are 0.33, 0.21 and 0.36 for black, white and brown respectively. This may not be absolutely correct if the distribution of the colours are considered. It is possible that alleles at two different loci interact to determine plumage colour in these birds.

On the beak and shank of turkeys, three colour types were identified (black, white and yellow) and were evenly distributed in all the areas surveyed. The percentage or relative frequencies of these colour types are 60.29, 26.19 and 9.52 percent for black, white and yellow respectively. Yellow colour in shank and beak is due to the presence of carotene and xanthophyll pigments in the feeds of these birds (3,12) .But the report of Card and Neshiem (13), showed that yellow colour reappears after laying had ceased suggesting that a genetic basis exists for the deposition of yellow pigment of both the shank and beak of these birds. Gene frequencies and inheritance ratio estimated on the basis of the pattern of inheritance revealed here showed that the frequency of the allele producing black shank and beak was 0.47 in the sample population, while the gene frequency of the allele for white/yellow was 0.53. These frequencies did not differ significantly from the expected.The frequency for

the gene allowing the deposition of yellow pigment estimated on the basis of the observed ratio was 0.52.

The ear lobe colour in indigenous turkeys was either red or white occurring at a relative frequency rate of 69.05 and 30.95 percent respectively. These colour types were identified in all the areas were turkeys were found. Red was the most common ear lobe colour. From the observed ratio, it is postulated that two alleles are segregating at the ear lobe colour locus, R is completely dominant to r.The frequency of R in the population surveyed was estimated as 0.44 while that of r was 0.56 showing that over 80 percent of the population surveyed are carrier of the recessive allele. Breed identification mark can easily be developed on the basis of this inheritance pattern and gene frequencies by selecting against the unwanted alleles.

CONCLUSION AND APPLICATIONS

In conclusion, local poultry species in Nigeria varied widely in plumage, shank and beak colours. These colours are under the control of alleles segregating differently at different colour loci. They could either be dominant, co-dominant or recessive resulting in colour patterns/combinations of different types in the birds concerned. The gene frequencies of these alleles varied with colour types and species. Gene frequencies and inheritance are useful in the development of trade marks especially in indigenous poultry birds where conscious selection effort has not been made. It helps in directing selection towards favourable criteria in development programmes. Conscious efforts should therefore be made to select trade marks in these local avian species using colours as breed characteristics. According to Adalsteinsson(14), the direct importance of colour in most breed has primarily been, the utilization of particular colour types as breed characteristics, the colour types being the trade mark of the breed. In addition, the pleiotrophic effect of colour genes has made breeding for certain colour types an aim of immediate economic value.

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