PIGMENT VARIATIONS AND THEIR CORRELATES IN BIRDS

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IN 1941 it was suggested by Keeler and King that certain coat pigmentation genes, in addition to determining melanic variations, produce multiple effects upon morphology, physiology, and behavior in the Norway rat, *Rattus norvegicus*. These conclusions were reached in view of behavior observations upon a captive gray strain of Norway rats and its several mutant—derivative strains, together with an examination of the late Dr. Donaldson's voluminous data on dissection of these same groups of rats. In 1942, Keeler published a detailed comparison of temperament in black (non-agouti) rats and their siblings bearing the gray coat color characteristic of wild Norway rats. The black mutants were found to be tamer than the grays by nature. More recent papers, Keeler (1947) have shown that this phenomenon occurs in numerous species of mammals.

An attempt to apply these findings to birds has yielded several conclusive cases. A study was made by Keeler, Hoffman, and Shearer (1949) upon many specimens of the faded-feather mutation in the Turkey, *Meleagris gallopavo*, and the faded mutants were found to have defective vision, broken or missing feathers, weak bones, and small body size.

A white, blue-eyed, mutant *Rhea americana* (about 6 weeks old) at the Philadelphia Zoo was found to be tame and unafraid of strangers as compared with its timid and excitable brown relatives.

Keeler (unpublished) has compared a pair of albino Collared Doves, *Streptopelia roseogrisea*, with a pair bearing the normal bisque coloration. The albinos have reduced ocular pigment and defective vision. They do not fly well. Their voices are relatively weak, and they are less active than the normals. After two weeks it was possible to hold the albinos on a finger, but the bisque doves would not perch on a finger even after an acquaintance of more than six months. A letter from Finn Salomonsen says that at the Copenhagen Zoo, where both varieties have been kept for many years, the albinos are less active and have weaker voices than the bisque variety.

Word from Dr. Y. Yamashina of Japan indicates that the albino Rice-bird, *Munia*, or more properly, *Lonchura*, has brownish eyes, is less active, and has a weaker voice than normally colored Rice-birds.

Because the above cases are so suggestive, it was decided that a survey of the literature ought to be made to learn whether or not other cases of pigment correlation have been recorded.

Realizing the enormity of the task of combing world ornithological literature, it was decided to limit the survey, with two exceptions, to English language articles that could be located in the libraries of Chicago. Thus, this study is merely a sample of the literature and is, therefore, incomplete. Strong's 'Bibliography of Birds' (1936–1946) was used as the source of the references.

The descriptions of mutant birds in this restricted literature turn out to be extremely unfortunate for our purposes in that most of them were written from observations made upon dead birds or their stuffed skins, and the behavior of most individuals was not noted. Often eye-color was not recorded, and there is much confusion between piebalds and complete albinism. For this reason an accurate classification of the references is impossible, but the most satisfactory categories seem to be: (1) pink-eyed albinism; (2) "pure" albinism (which undoubtedly includes many piebalds); (3) "pale"; (4) white spotted; (5) "mottled" in several shades; and (6) miscellaneous. The results of this survey of literature have been classified according to these categories in Table 1.

In Table 1 it will be noted that the 172 recorded pigment variations have no predilection for particular orders of birds but are scattered from the lowest to the highest in evolutionary development. It will also be observed that in those groups such as the Anatidae, Phasianidae, Columbidae, Corvidae, Icteridae, Fringillidae, Turdidae, and others, mutations have been recorded that fall into most of the categories that we have employed.

Again, it should be pointed out that these types of mutations appear in general to correspond to those most commonly found in mammals, namely, true pink-eyed albinism, dilutions (especially similar to pink-eyed buff), and various types of piebald. Less common in mammals are the other types of coat color mutation which would correspond to "miscellaneous" of our classification. In Table 1 these cases are seen to be rare.

In the literature one encounters in a few cases casual mention of the correlated characteristics of individual mutants. Unfortunately, the mutants were usually shot, and hence behavior observations over a period of time were not made.

Of these cases, seven ought to be noted. The details of these mutants are given in Table 2.

No matter how deficient they may be, these observations suggest that some of the mutants of ornithological literature exhibit morphological, physiological, and behavioristic changes quite in line with those found in mutant mammals and birds following extended observa-

TABLE I

RECORDED INSTANCES OF PLUMAGE MUTATIONS IN BIRDS

Miscellaneous	*Mottled*	*White-spotted*	*"Pale"*	*"Pure" albino*	*Pink-eyed albinism*	Family of bird involved
		1				Gaviidae (Loons)
1	1					Laridae (Gulls, Terns)
				1		Sulidae (Gannets)
	2	1				Phalacrocoracidae (Cormorants)
	1	†4†	4	3	1*	Anatidae (Ducks, etc.), † = 2 mutants, * = 5 mutants)
1				1		Gruidae (Cranes)
		1	1			Rallidae (Rails, Coots)
	1	1	3	1		Scolopacidae (Snipes, etc.)
		1				Charadriidae (Plovers), Aphrizidae (Surf birds)
		1†				Haematopodidae (Oyster catchers) († = 2 mutants)
	1		1			Tetraonidae (Grouse)
	1					Meleagridae (Turkeys)
	2	1	3†	3		Phasianidae (Pheasants) († = 2 mutants)
	†2*	2		2		Columbidae (Pigeons) († = 5 mutants, * = 12 mutants)
	1			2		Cathartidae (New World Vultures)
	1			3		Buteonidae (Hawks)
		1	2			Falconidae (Falcons)
	1	1				Strigidae (true owls)
1						Psittacidae (Parrots)
1			2			Picidae (Woodpeckers)
2				1		Trochilidae (Hummingbirds)
				1		Tyrannidae (Tyrant flycatchers)
				2		Alaudidae (Larks)
	2	4	7	5†	1	Corvidae (Crows) († = 2 mutants)
		1	3		1	Sturnidae (Starlings)
	††9s‡	5*	1	1	2†	Icteridae (Blackbirds, Orioles) († = 4 mutants, * = 40% of flock, †† = 4 mutants, s = several mutants)
4*	5	†12†	3	2†	2†	Fringillidae (Finches) († = 2 mutants, * = 3 mutants)
	1		1	1s	2	Hirundinidae (Swallows) (s = several mutants)
	1					Vireonidae (Vireos)
1		2		1	1	Mniotiltidae (Warblers)
1				1		Motacillidae (Wagtails)
	2					Mimidae (Mimic thrushes)
		2	1			Troglodytidae (Wrens)
1		1†				Paridae (Titmice) († = 2 mutants)
			1			Sylviidae (Kinglets and Gnatcatchers)
1	†3††	2	2		1	Turdidae (Thrushes) († = 2 mutants, †† = 3 mutants)
14	37	44	35	31	11	SUBTOTALS
					172	TOTAL

tions. The birds may be noticeably large or small; they may be wilder or tamer than normal; they may have reduced vocal powers.

In the literature there are several references that merit special consideration.

Darwin (1890) described a physiological correlation between feather coloring and degree of development of down at hatching in pigeons. He says: "Mr. Tegetmeier has informed me of a curious and inexplicable case of correlation, namely, that young pigeons of all breeds which when mature become white, yellow, silver (i. e., extremely pale blue), or dun colored, are born almost naked; whereas pigeons of other colours are born well clothed with down."

TABLE 2

Bird	*Color*	*Morphology, physiology, behavior,*
Coot (*Oidemia* sp. ?)	dirty white; underparts of wings bleached brown; eyes black	head of flock
Vulture (*Cathartes* sp.)	white	small, but leader of flock
Hawk (*Buteo* sp.)	partial albino	showed fear of other hawks
Red-tailed Hawk (*Buteo i. borealis*)	albino	extra large and robust; 25 years old
Swamp Sparrow (*Melospiza georgiana*)	male; white except one dark feather	very fat; very shy
Blue Titmouse (*Parus caeruleus*)	head, neck, wings, and tail French gray; under parts canary yellow; eyes pink	size small; semi-tame
Thrush (species ?)	red breast	wilder bird; more reserved vocal powers

Maw (1935) detected in chickens what may turn out to be larger body size associated with silver feather color or slow feathering, the genes for which two characters reside on the sex chromosome. The differences were not considered statistically significant, and because the silver feather color and slow feathering genes entered the cross on the same chromosome, it was concluded that there also resides on the same chromosome a gene for large body size. But because the silver color gene and the slow feathering genes were not separated and studied further, it is impossible to say whether the size effect noted was due to a linked gene or was a pleiotropic effect of either the silver color gene or the slow feathering gene.

After 18 years in captivity a strain of Mallard Ducks described by Hunter (1939) produced a light-feathered, generally-recessive mutation. Light Mallards were interbred. Of 42 eggs set: four were infertile; seven died too early to determine feather color; 27 light Mallards died between the 23rd day and hatching time; four light

Mallards hatched but died within a few days. It would appear that a semi-lethal weakness of embryo and duckling is associated with the light gene. A back-cross was made of (Light Mallard by Fawn Indian Runner) by Light Mallard. A total of 59 eggs were set: eight were infertile; seven died too early to determine color; 24 of Normal Mallard color and 15 of Light Mallard color died between the 23rd day and hatching time; two Normals and three Light Mallards hatched and died within a few days. As compared with this high mortality among ducks bearing the Light gene in simplex or duplex, a cross of Light Mallard to Fawn Indian Runner is instructive. Twenty-nine eggs were set: three were infertile; five died too early to determine the color; ten Blue-gray blends died between the 23rd day and hatching time; ten Blue-gray blends and one Light Mallard were hatched.

These experiments were not carried far enough to decide whether the semi-lethal effect is due to the Light gene itself or to another gene linked on the same chromosome.

Probably the most satisfactory case in the literature, in which mutations among wild birds have been observed, is that reported by McIlhenny (1940). This observer watched 12 nests of Mockingbirds—all belonging to a male and his two successive mates. The male and his first mate were apparently heterozygous for albinism. Of their 43 offspring hatched, 18 were albinos and 25 were normal. "The albinos were deficient in sight, weak in voice, and not as active on the wing as their normal nest-mates. All normal young except two survived. No albinos survived."

But lest the reader should get the idea that all pigment variations are associated with weakness we should mention the description of Hachisuka's dark mutant pheasant (Legendre '1941): "The bird is large and robust. As a game bird, the Dark Pheasant presents itself as flying high and fast. Its weight is greater than that of ordinary pheasants."

Although the specific physical, physiological, and behavioristic defects of mutant birds are seldom recorded, ornithologists have a definite feeling about the matter that is well summed up in a series of articles by Legendre (1935):

"In nature, cases of albinism are often observed and collections contain numerous specimens. These cases are perhaps more frequent than we suppose, because one must think that these birds, too easily seen, are quickly eliminated by their enemies, all the more because they represent specimens of reduced vitality, since albinism implies degeneration."

Again this author says: "But the breeders are not content with modifying the coloration of the animals that we have just enumerated. The transformation has been more complete, and among others varieties have been created by alterations carried out upon the size, bodily form, or a part of the body, and the voice." Here Legendre recognized changes in morphology and behavior, but does not specifically associate them with pigment alterations.

Of particular interest is Legendre's description of the albino mutant of the Collared Dove, *Streptopelia roseogrisea*,—"We may note that aside from the Canary and the Undulated Parakeet, there have been domesticated few cage birds. It is always necessary to mention the Collared Turtledove, raised since long, but which scarcely interests the amateurs, because it always remains with its single white variety. This white variety was much studied in the past because of the gentleness of the bird. It was the symbol of faithfulness; and the gift of a white Turtledove to a lady much resembled a betrothal.—Occasionally there have been found in the same nest one youngster with gray plumage beside a white one."

CONCLUSION

A sample of ornithological literature and recent observations demonstrate that certain pigment variations in birds possess correlates in the modification of morphology, physiology, and behavior, as shown previously to be the case in mammals.

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