Bats: Sensitivity to DDT

Abstract. *Big brown bats,* Eptesicus fuscus, *were fed single doses of varying amounts of DDT in corn oil injected into meal worms. All the doses of DDT fed to the bats, 40 milligrams or more per kilogram of body weight, were lethal. Within a few hours to 13 days after being dosed, the animals developed convulsions; some bats survived up to 3 days after the onset of the symptoms of poisoning. Bats appear to be far more sensitive to DDT than any other mammal yet tested.*

Concern about recent decreases in bat populations in the United States (*1*) has caused us to begin investigating the possible effects of pesticides on bats. Because of its widespread agricultural, public health, and domestic applications, DDT was chosen as the initial pesticide for study.

Table 1. The effects of DDT on the bat *Eptesicus fuscus.*

Sex	Wt. (g)	Dosage (mg/kg)	Time after being dosed (hours)	
			Until tremors	Until death
M	17.9	800	<2½	2½–18
F	22.5	400	6–7	18–28
F	25.0	335	7	50–66
F	21.0	200	3½	8–19
F	19.5	200	3–19	23–35
F	17.5	150	<3	6–22
F	19.5	100	3–6	6–22
F	19.3	100	5	11–23
M	16.2	100	10–24	31–59
M	14.6	100	48–55	118–130
M	14.7	100	49	108–120
M	14.0	80	<10	10–24
F	23.0	80	10–24	31–47
F	25.0	80	10–24	50–73
F	18.0	75	10–23	51–61
M	14.9	60	9–23	31–46
F	25.4	60	47–73	120–123
F	26.7	60	73–76	126–143
F	19.0	50	11–23	34–50
F	20.5	50	124–143	193–216
M	14.3	40	<9	30–46
M	14.0	40	30	46–72
F	24.3	40	30–46	97–107
F	20.5	25	173	245–262
F	19.0	25	*	Survived†
F	21.0	25	20–44	Survived†
F	18.9	20	192–216	Survived†
F	23.5	20	322–346	Survived†
F	24.9	20	192–216	240–264
F	19.5	0	*	600–624
M	14.3	0	*	Survived†
F	25.3	0	*	Survived†
F	15.2	0	*	Survived†
F	16.8	0	*	Survived†
F	14.4	0	*	Survived†
F	15.9	0	*	Survived†
F	17.7	0	*	Survived†

* Tremors never observed. † Bat released in apparent good health at end of experiment.

Bats (*Eptesicus fuscus*) were captured during May 1964 in attics of several houses in Georgetown and Lexington, Kentucky. They were brought into the laboratory, weighed, banded, and put into individual cages consisting of wide-mouthed gallon jars containing a bedding of wood shavings covered with filter paper. A small dish of water was placed in each cage. Solutions of technical-grade DDT in corn oil were prepared in such concentrations that the calculated dose would occupy a volume of at least 0.50 ml. The calculated dose was taken up in a 1-ml tuberculin syringe. By means of a 26-gauge needle, the DDT solution was injected in approximately equal portions into five to eight meal worms (*Tenebrio molitor*). Each worm was fed to the test animal immediately after injection, care being taken to ensure that the entire larva was consumed. The injected worms were readily eaten. The bats actually seemed to prefer the worms injected with corn oil to normal meal worms. Bats used as controls were fed worms injected with corn oil only. The bats were afterward fed on five to ten adult *Tenebrio* daily, as long as they were able to eat. Observations were made at intervals of 24 hours or less. The experiment was terminated after 28 days.

The results of the experiment are shown in Table 1. Although some bats receiving the highest doses showed tremors as early as 2½ hours after dosing, most showed initial tremors on the second morning after feeding. Two bats given low (though lethal) doses of DDT showed initial tremors as late as 5 and 7 days after being dosed.

Behavior patterns were similar in all cases of poisoning. Occasional tremors were followed by continual and progressively worsening convulsions. Near death, behavior was reduced to an occasional tremor. Controls were nearly always quiescent.

Our bats seemed far more sensitive to DDT than other mammals. For example, the oral LD_{50} (lethal dose, 50 percent effective) for mice has been reported to be 400 mg/kg (*2*); for rats, 150 mg/kg; and for rabbits, 300 mg/kg (*3*).

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Sex-Linked Albinism in the Japanese Quail

Abstract. *From a single white* Coturnix *chick hatched in August 1963, a white colony has been developed. The results of breeding experiments are consistent with the view that the albinism is sex-linked and recessive. It appears likely that the mutation occurred in the first white female hatched, or her sire.*

Although Japanese quail (*Coturnix coturnix japonica*) are being used increasingly in physiology and genetics research, few genetic variants of any kind have been reported for this species.

A single white, pink-eyed quail chick appeared in August 1963 in a hatch of several thousand normally pigmented quail. The parentage was unknown, but the stock has been maintained at this laboratory for several years, and many thousands of normal chicks have been hatched. The down was blond, similar to that of a Leghorn chick. There was a suggestion of the normal pattern of longitudinal stripes on the back, but closer examination revealed no darker feathers in these areas. The eyes were bright pink, and the bird appeared to be slightly more photophobic than its normal hatchmates.

When the bird was about 1 month old and the adult plumage was well established, it was evident that it was a female. Light buff-colored spots again suggested the pattern of the normally pigmented bird, but feathers from such areas, on microscopic examination, contained no melanin or other pigment granules (Fig. 1).

The white bird began to lay at 7½ weeks of age. Both eggshell and yolk were pigmented normally (the yolk was deep yellow-orange, the shell was light tan mottled with brown and black spots). After an early aggressive period, during which the bird was laying but would not mate, egg production stopped, and she underwent a partial molt. When laying again commenced, a normally pigmented male from the general popu-

lation was accepted as a mate. At this time a new quail diet was introduced which contained a higher percentage of calcium and phosphorus than the diet, intended for young turkeys, on which the quail were previously fed (*1*). On the new diet the albino bird maintained 100 percent production (an egg every day) for the next 6 months—a phenomenal record compared with what we have learned to expect from flocks of quail of the same age maintained on the usual "turkey starter" diet.

From the first mating, 35 normally pigmented chicks were hatched. When the first F_1 male reached maturity, it was backcrossed to the albino bird. The first hatch from this mating yielded four white chicks, four dark, and two which died before hatching (one white, one dark)—exactly the expected color ratio from a backcross of a heterozygous individual with his homozygous recessive parent. Of 63 chicks either hatched or developed far enough that their color could be determined, this backcross has yielded 37 dark and 26 white chicks.

Meanwhile, crosses among the remaining F_1 offspring of the first mating have yielded, to date, 1150 dark and 363 white chicks. The slight, but not statistically significant, shortage of white chicks from the 25 percent expected, as well as the disparity in the previous backcross, where 50 percent white would be expected, may be partially explained by the difficulty of identifying white chicks that died in early embryonic stages, when the pigment of the eye would identify a normal chick, but an albino would be missed.

Birds that died were autopsied, and all F_2 white birds proved to be females. It thus appeared that the trait might be sex-linked. Since in birds the female is the heterogametic sex, the recessive gene would thus pass from the single sex chromosome of the white dam to her heterozygous, normally pigmented sons, and thence to half of her granddaughters which would be white, and half of her grandsons, which would be dark but heterozygous. According to this hypothesis, white males could only be obtained from a mating of white × white individuals, or from a backcross of an F_1 male to a recessive white female. In the latter case, half of the male offspring would receive one recessive gene from the heterozygous sire as well as one from the albino dam. This explanation is consistent with all of the breeding results obtained in our experiments to date (Table 1) (*2*).

Limited viability of the white, but not of the dark, chicks proved to be a problem. All white chicks from several hatches died. Typically, the white chicks hatched in expected numbers, although some appeared small and weak. However, most died at 3 to 4 days of age and would thus be classified as "starve-

Table 1. Results of breeding experiments with albino quail.

Parents ♂		Parents ♀	No. of young	No. dark	No. white
Dark *A1⁺A1⁺*	×	White *a1O*	35 (F_1)	35*	
Dark F_1 *A1⁺al*	×	White *a1O*	63 (backcross)	37*	26*
Dark F_1 *A1⁺al*	×	Dark F_1 *A1⁺O*	1513 (F_2)	1150*	363†

* Males and females included. † Females only produced.

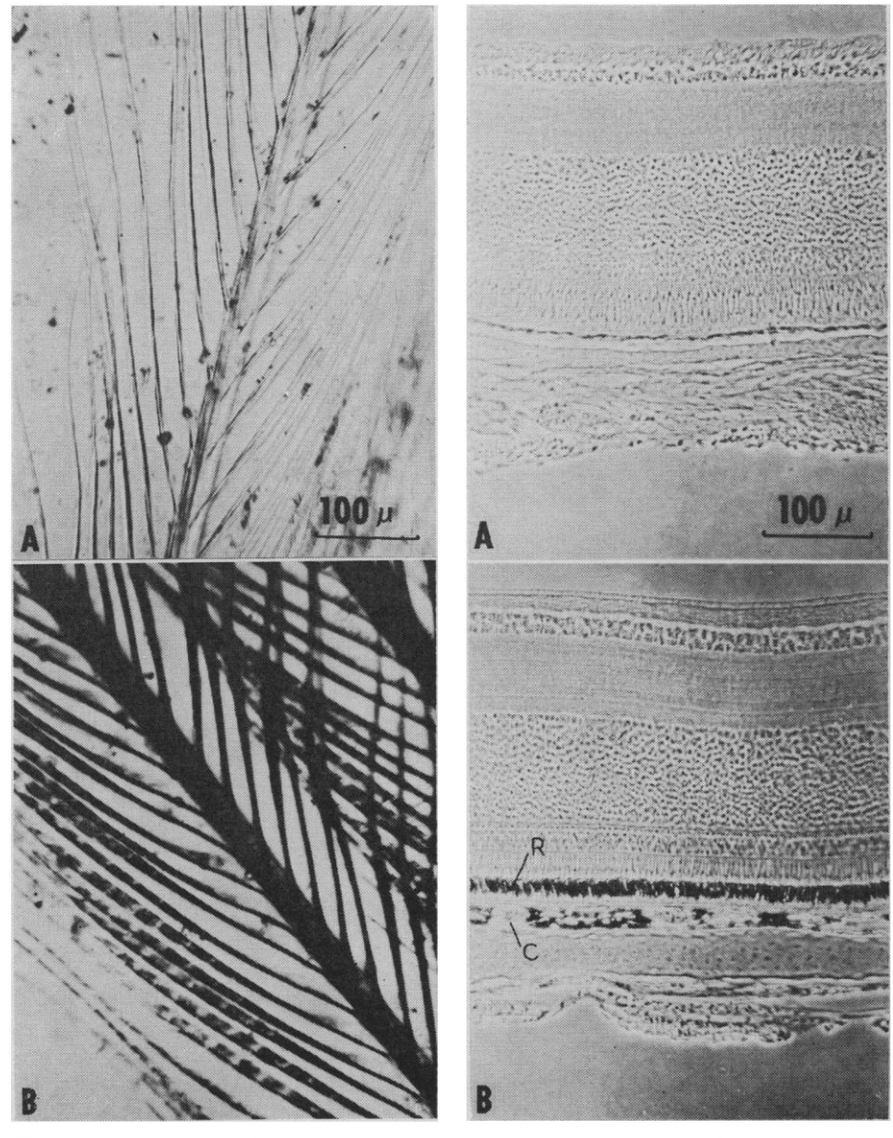

Fig. 1 (left). Portion of a feather from an albino (*A*) and normal (*B*) quail, showing the complete lack of melanin granules in the barbules of the albino quail. Scale, 100 μ. Fig. 2 (right). Meridional section showing part of the posterior eye wall of an albino (*A*) and normal (*B*) quail chick. Note the lack of pigmentation in the retina and choroid (unstained, dark M phase contrast). *R*, pigment epithelium of retina; *C*, choroid. Scale, 100 μ.

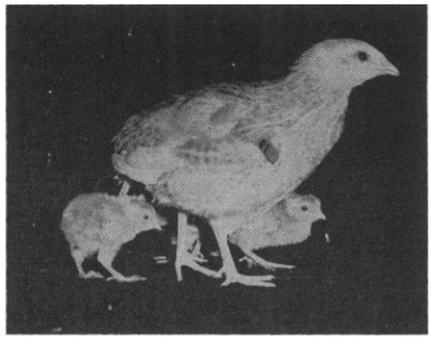

Fig. 3. Adult albino female and newly hatched chicks. The "ghost spotting" can be seen on the wing and back of the adult, and the faint stripes on the back of the chick, both apparently due to structural color only.

outs," failing to find the food and water at the time when yolk sac nutrients became depleted. While disease or suboptimum care cannot be ruled out, and the intial inbreeding necessary to establish the strain may have brought other, non-linked lethal genes to phenotypic expression, it seems most likely that the albino gene itself is semilethal.

Mutations to albinism have been reported to occur in the turkey (*3*) and in several breeds of chicken: white Wyandotte (*4*), Plymouth Rock (*5*), and single-comb white Leghorn (*6*). In these birds, the gene was found to be sex-linked, and in some cases produced only imperfect albinism—that is, some melanin was found in the eye, although the feathers were white. Mutant barred Plymouth Rock birds exhibited "ghost barring" on some feathers. Such birds had bright pink pupils with the iris varying in color from pink to chocolate to pale blue. The mutation was semilethal in some instances, while viability of albino birds was normal in other cases.

It is suggested that the new gene be designated *a1*, and its allele for normal (wild type) color, $A1^+$. This designation follows the pattern set for sex-linked albinism in chickens and turkeys by Hutt and Mueller (*3*). It is not yet known in the present case whether low viability or semilethality may be part of the phenotypic expression of the gene for albinism. The appearance of the trait could be explained by the hypothesis of a single mutation in the first albino bird, or her sire.

The "ghost spotting" of the wing and back feathers of albino quail (Fig. 3) appears to be due to structural color only (Fig. 1). The eyes of several albino and normal chicks were enucleated at hatching, fixed in Bouin's fluid, and sectioned at 8 μ. Viewed unstained with dark M phase contrast optics, the eyes from albino birds showed no trace of black pigment in the pecten, retina, or choroid (Fig. 2). A very small amount of light-brown pigment was detected in the ciliary body and iris in one case. Presence of a minimum amount of melanin could explain the dull reddish-brown appearance of the iris in some of the white birds now maturing.

Albino males, from backcross matings, show at maturity no trace of the russet breast pigmentation characteristic of normal male *Coturnix*. Preliminary results of matings between such white male birds and albino females confirm the hypothesis presented. White chicks only were hatched; thus, the white parents are shown to breed true for the trait.

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Mirror Display in the Squirrel Monkey, Saimiri sciureus

Abstract. *Male squirrel monkeys may display the erect phallus under various conditions of courtship, aggression, and salutation. One variety will display consistently to its reflection in a mirror. Such display has a typical pattern and can sometimes be triggered by reflection of but one eye. A mirror display test has been designed for experimentation on the brain.*

Squirrel monkeys (*Saimiri sciureus*) are among the most common primates of Central and South America. They are the smallest of the Cebidae and comprise several closely related species (*1*). We have found them most useful for studies of the brain and behavior and have prepared a brain atlas for such work (*2*). Figure 1 shows the faces of two varieties most commonly used in this laboratory. The circumocular patch of the animal on the left is lighter and comes to a peak like a Gothic arch. In contrast, the eye patch of the animal on the right is rounded above like a Roman arch. Accordingly we informally distinguish these two types as Gothic and Roman.

Our studies of these monkeys have revealed that the male may display the erect phallus in a variety of situations, four of which have been identified as (i) aggressive, (ii) courtship, (iii) distant, and (iv) mirror display (*3*). In the communal situation the displaying animal makes a forward encounter with a female or another male, spreads the thigh, and thrusts the erect phallus towards the face of the other animal. Display to a female presumably serves as a signal in courtship behavior, as it is seen preceding attempts at copulation. In the case of two males, however, it appears to be primarily an aggressive act because it occurs in exerting and establishing dominance. If the recipient does not remain quiet and submissive during the display, it may be viciously assaulted. In social groups the quantification of the number of aggressive displays among respective males has provided a better measure of dominance than the outcome of rivalry for food (*3*).

We have observed no significant differences in the pattern of the aggressive and courtship display among various squirrel monkeys. However, the same is not true of distant display and its counterpart mirror display. Distant display is so-called because it is performed at a distance between two or more animals, seemingly as a kind of greeting. Among separately caged animals housed in close quarters it is precipitated when cages are rearranged or when a new monkey is introduced. This display appears to be peculiar to the Gothic monkey (Fig. 1, left) which also performs a similar display to its reflection in a mirror. Typically it will approach the mirror, climb the side of the cage, vocalize softly with the corners of the mouth retracted and the head tilted to one side, spread one thigh, and make a number of thrusts forward with the tumescent phallus. At the same time there may be a few spurts of urine. During and after the display it will frequently scratch various parts of the body with its fore and hind paws. A