A FIELD STUDY OF THE MOCKINGBIRD'S WING-FLASHING BEHAVIOR AND ITS ASSOCIATION WITH FORAGING

BY JACK P. HAILMAN

THE peculiar "wing-flashing" behavior of the Mockingbird (*Mimus polyglottos*) has been the subject of much study and discussion among American field workers, and yet there is little agreement on the biological function of this behavior. The most prevalent theory, perhaps, is that the motions are associated with hunting insects (e.g., Gander, 1931; Hebard, 1949*a*, 1949*b*; Wampole, 1949; Brackbill, 1951). However, Sutton (1946) believed that wing-flashing is an alarm reaction, because several observers reported it when birds were confronted with strange objects or situations (e.g., Michener and Michener, 1935:106; Laskey, *in* Sutton, 1946; and Sutton, 1946). Recently Brackbill (pers. comm.) has come to believe that the behavior is produced by hostile or fear motivation. Others have termed wing-flashing a sexual display (Forbush, 1929:320), and one observer (Tomkins, 1950) concluded that "it has no present value to the species."

Disagreement concerning the form of the behavior as well as its function has arisen. Sutton's (1946) painting shows a Mockingbird with its wings held high above its back, but Wampole (1949) describes the wings as being moved horizontally. Many authors do not describe the motions they call "wing-flashing."

METHODS

Field observations were made from June to August, 1958, at eight localities in the suburbs of Washington, D.C., and from April to July, 1959, in Norfolk, Virginia. The 1959 study was of adults only, since it was terminated before general fledging time, and involved only about three pairs of birds; the 1958 observations were of both young and adults.

For statistical purposes, each individual Wing-flash is assumed to be an independent observation. This assumption seems valid, because each Wing-flash is usually spaced from the next by a definite time interval, even when no other motions intervene.

Standard statistical methods are used. Probability of a proportion in a sample was determined by either the exact binomial or the normal approximation, as noted. Comparisons of proportions from two samples are made with the proportions test outlined by Wallis and Roberts (1956:429), utilizing the Yates correction for an uppertail probability; this is valid because the direction of the alternative hypothesis was anticipated. Throughout, probabilities of below .01 are taken as significant, those from .01 to .05 as bordering significance, those of .05 to .10 as possibly indicative of difference, and those above .10 as insignificant.

Since the 1959 birds were drawn from a different statistical population than were the 1958 birds (different in geography, time of study, time of year, and age composition), data from the two populations are compared only with qualification. It is also possible that any systematic errors by the

observer (say, in recording the number of hitches/Wing-flash) were different in 1958 and 1959. Only the corresponding segment of 1958 population is compared to 1959.

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FORM OF WING-FLASHING

The term "wing-flashing" is fairly descriptive of the Mockingbird's behavior, and has been so frequently used in the literature that a change in terminology here could not be justified. Nevertheless, the term has been used to designate a variety of unrelated motions (see discussion in Hailman, 1959), so that some distinction is necessary. For the remainder of this paper, the capitalized term "Wing-flash(ing)" refers to the specific behavior pattern of the Mockingbird described below; the term "wing-flashing" refers to behavior previously described in the literature which cannot definitely be assigned as true Wing-flashing, and as a general term for discussing similar wing motions of other species.

Wing-flashing of the Mockingbird takes place as follows: the bird stands on the ground with body held in normal position (spinal column at an angle of about 35° with the ground), and with its head forward, begins the wing motions. Sometimes birds tilt the head slightly to the side or down in front, but most birds look nearly straight ahead. The wings are opened simultaneously in a series of distinct motions, or "hitches." The number of hitches is variable in a given individual, and is usually one to three, occasionally four or five. The direction in which the wings open is also variable, which may account for some of the disagreements in the literature. Sometimes the wings seem to be opened nearly vertically above the bird; at other times nearly horizontally, the latter occurring especially when the bird is running while Wing-flashing (which is rare). When the number of hitches is few, the direction is not evident.

When the wings are hitched open, the white patches appear to "flash," hence the original term. (However, quite similar "wing-flashing" occurs in other species of the Mimidae which have no wing patches. See Whitaker, 1957, and wing-flashing in other species, below). Once the wings have been extended, they are brought back to the body in one smooth, quick and direct motion. This closure concludes the Wing-flash proper, and behavior which follows is variable.

Two principal hypotheses were investigated: that Wing-flashing is a social or sexual display, and that Wing-flashing is a foraging motion. If Wing-flashing displays the white patches as a signal to other birds, it seems reasonable that (a) the presence of other birds would elicit Wing-flashing, (b) Wing-flashing would usually be performed only when other birds are present, and (c) the performance would affect in some way the behavior of birds present, especially other Mockingbirds. It was quickly evident from field study that none of these conditions existed. Finding no other evidence that Wing-flashing serves a communicative function, I turned to the second possibility.

It was necessary to find how the Mockingbird forages, and then whether or not foraging and Wing-flashing were associated, and if they were, what the nature of the association was. Feeding of adults on the ground during spring and summer in general resembles the behavior of Robins (*Turdus migratorius*), running over bare areas, stopping and occasionally striking. Ground foraging of the Mockingbird may be divided into three principal patterns: (1) look down into the grass (to spy prey?); (2) run or hop a few inches, presumably when no prey is seen in the immediate area; and (3) strike. The association of these three motions with Wing-flashing was investigated in detail.

Wing-flashing and Foraging on the Ground.—If, as suggested by several previous observers, Wing-flashing startles insects or other prey into betraying themselves, it would be expected that Mockingbirds would often strike just after Wing-flashing. Therefore, quantitative data were gathered on the number of times Mockingbirds struck after Wing-flashing, the number of times they did not, and what the birds did if they did not strike. The data are arranged in columns corresponding to the category of behavior following the Wing-flashing (Tables 1–5). These data were also divided into rows according to the number of hitches in each Wing-flash.

The 1958 results (Table 1) show an extremely high association (about 96 per cent) of Wing-flashing followed by one of the motions of foraging (80 versus three non-foraging occurrences). The probability of a difference this great or greater by chance alone is significantly small to be discounted ($P = < .0001$ by exact binomial). In this sample about one Wing-flash in five was followed by strike at prey, and about half of these strikes were seen to produce captures.

I noticed in the 1958 study that a bias was introduced into my field data because often after Wing-flashing a bird ran or looked down, and then struck. Because I took no systematic notes on this "second" motion after Wing-flashing, these sequences are not reflected as strikes in Table 1. There-

TABLE 1
WING-FLASHING BY ADULTS ON THE GROUND IN 1958

Wing hitches	Behavior following Wing-flash			
	hop/run	look	strike (capture)	other
1	7	6	2 (2)	2[1]
2	15[2]	12	6 (3)	0
3	8	13	6 (2)	1[3]
4	1	2	0	0
5	1	1	0	0
Total	32	34	14 (7)	3

[1] One bird flashed immediately after strike, but gave no reaction after Wing-flash. Other bird gave no reaction.
[2] One bird ran, gave the "predator warning call" (Hailman, in prep.), and stopped foraging.
[3] Bird appeared to be frightened while Wing-flashing and flew away quickly.

fore, in re-evaluating the behavior with the Norfolk Mockingbirds in 1959, I created two new categories: "hop/run–strike" and "look–strike."

Table 2 also shows that the association of Wing-flashing with foraging motions (about 99 per cent) in 1959 is highly significant (256 of 258 observations; probability of chance difference: $P = < .0001$ by exact binomial). In fact, a test on the proportions shows that the 1959 birds' Wing-flashes may have been more closely associated with foraging than were the 1958 Wing-flashes ($P = .087$). In 1959, well over two-thirds of the Wing-flashes were followed by actual strikes, either immediately or with a short run or look-down intervening. This number is far above that expected by chance (191 strikes versus 67 nonstrikes is highly significant at $P = < .0001$ by the normal approximation to the binomial) and is significantly greater than strike occurrence by the 1958 birds ($P = < .001$ by proportions test). Strike success was not recorded in 1959.

It is interesting to note the details of "non-foraging" Wing-flashes (notes to Tables 1 and 2). The observations suggest that when Wing-flashing was not followed directly by foraging behavior, some other motivating factor was present, such as frightening stimulus, presence of young birds, etc., which conflicted with foraging. The bird (Table 1) which Wing-flashed after striking may have been stimulated by some sort of "surplus" motivation; in any case, the observation is generally within the context of foraging.

Furthermore, the average intensities (as measured by the number of hitches/Wing-flash) of the behavior pattern seem to be higher when associated with foraging than when not. In Table 1, the mean intensity of "foraging" Wing-flashes is 2.30 hitches, whereas the mean intensity of "non-foraging" Wing-flashes is 1.67. In Table 2, the mean foraging intensity is 2.46 and the mean nonforaging intensity is 1.00. The few nonforaging

TABLE 2

WING-FLASHING BY ADULTS ON THE GROUND IN 1959

Wing hitches	Behavior following Wing-flash					
	hop/run	look	hop/run–strike	look–strike	strike	other
1	10	12	4	0	45	2[1]
2	9	8	1	0	41	0
3	4	6	4	4	45	0
4	6	9	5	2	40	0
5	1	0	0	0	0	0
Total	30	35	14	6	171	2

[1] One bird gave no action; other bird looked at young Mockingbird nearby.

observations in each case preclude a meaningful statistical comparison, but the consistent large differences are indicative of lower intensity in nonforaging situations.

The Wing-flashing of Mockingbirds on the ground is used as a standard by which to compare Wing-flashing in other instances recorded in 1958. Due to the variables already discussed, it is not appropriate to use the 1959 data for exact statistical comparisons. However, the 1959 data (Table 2), if anything, show a closer connection between Wing-flashing and foraging (especially striking) than do the 1958 data (Table 1), and a mean intensity of the same order.

Wing-flashing Aloft.—A few times Mockingbirds were seen to Wing-flash while perched on fences, bushes, trees, and other places above the ground; these observations are summarized in Table 3. During the 1958 study period, Wing-flashing aloft accounted for about 10 per cent (%2) of all adult Wing-flashing seen (Tables 1 and 3). Aloft, eight Wing-flashes were definitely associated with foraging on the ground, while the other was followed by a strike and capture aloft. The connection of Wing-flashing and foraging is thus 100 per cent (%, highly significant at $P = < .002$ by exact binomial), although this perfect correlation in a small sample does not indicate a greater connection of Wing-flashing and foraging while aloft than on the ground. (Proportion test with Table 1 shows $P = .098$, which does not indicate a significant difference.)

Again, taking hitches as a measure of intensity, it is possible to compare the intensities of Wing-flashes aloft with those on the ground. The 3-hitch level was the highest given by aloft birds, which suggests that motivation is less than on the ground. Calculating the mean intensity of Table 3 (foraging) Wing-flashes reveals a mean of 1.78, compared to a mean of 2.30 of foraging intensities of Table 1, also suggesting a difference.

TABLE 3

WING-FLASHING BY ADULTS PERCHED ALOFT IN 1958

Wing hitches	Behavior following Wing-flash				
	look at ground[1]	fly to ground	fly to ground and strike[2]	strike aloft[2]	other
1	2	0	0	1 (1)?	0
2	3	1	1 (1)?	0	0
3	0	1	0	0	0
Total	5	2	1 (1)	1 (1)	0

[1] All birds perched at heights less than 6 feet.
[2] Numbers in parentheses indicate captures, as in Table 1.

WING-FLASHING BY FLEDGED YOUNG

During the 1958 study period, 41 Wing-flashes by about seven fledged young Mockingbirds still in the "dependency period" were observed (Tables 4 and 5), 32 of which were performed on the ground. The "dependency period" is tentatively defined as that time after which young animals have left the nest, but during which time they are dependent upon at least one parent for food and/or protection (Hailman, 1960*a*), and seems to be an important time in the development of behavior.

Considering only the Wing-flashes on the ground (Table 4), 21 of 32 Wing-flashes were followed by one of the three motions of ground foraging (probability of chance difference by normal approximation $P = .056$, which borders significance). If the "begging" were included as a category of foraging, the proportions would be considerably larger; this treatment is considered below. Considering the "beg" column as "non-foraging" observations, the percentage of foraging Wing-flashes is considerably lower in fledged young than in adults (about 63 per cent versus 96 per cent). A proportion

TABLE 4

WING-FLASHING BY FLEDGED YOUNG ON GROUND IN 1958

Wing hitches	Behavior following Wing-flash				
	hop/run	look	strike (capture)	beg[1]	other
1	3	4[2]	4 (0)	1	4
2	0	2	2 (0)	0	1
3	1	0	3[3] (2)	4	1
4	0	2	0	0	0
Total	4	8	9 (2)	5	6

[1] All birds gave species begging call.
[2] One bird gave begging call.
[3] Two birds gave begging call.

test on the raw data shows this difference to be highly significant ($P = < .001$).

Furthermore, the Wing-flashes of fledged young seem to produce a lower strike success and have a lower average intensity. Strike success was only two out of nine, but is not significantly lower than that of the 1958 adults (Table 1), which was seven out of 14 ($P = .175$ by proportions test). Perhaps the small samples obscure a difference. The mean intensity of fledged young foraging Wing-flashes is 1.86, and is lower than the mean intensity for adults (2.30 of Table 1). Further, the mean intensity for the "beg" column in Table 4 is higher (2.60), and that of the "other" column lower (1.50), than the foraging intensity, although the small samples preclude meaningful statistical comparison.

Finally, there are several other considerations of Table 4 to be noted. First, the young showed a new behavior, "begging," following Wing-flashing, and this category accounts for about 12 per cent (5/41) of the observations. Second, the "other" behavior is not readily attributable to conflicting drives or distractions, as were those of adults. That is, when a young bird did not forage or beg after Wing-flashing, it simply did nothing noticeable. The Wing-flashing appeared to be largely undirected and irrelevant. Last, several foraging observations in Table 4 were accompanied by the screech-like "begging-call" of the species, the same as is given while the young are actually begging (notes to Table 4).

If, as suggested above, the begging observations are considered to be part of "foraging" behavior, the proportion of "foraging" Wing-flashes (26 of 32) becomes highly significant ($P = < .001$ by the normal approximation). This also makes proportions of "foraging" behavior similar to that of adults —although still not as high (about 81 per cent versus 96 per cent) and statistical tests on the raw data show the differences to be insignificant ($P = .165$ approximately, by proportions test). Including begging also raises the mean intensity of the young's foraging Wing-flashes to 2.00 which is similar to the 2.30 mean of adults. Thus the parameters of Wing-flashing by fledged young on the ground resemble those of Wing-flashing by adults, when the former group includes "begging" as a foraging response.

A few observations were made of fledged young Wing-flashing while perched aloft (Table 5). These constitute 18 per cent (5/30) of the observations of fledged young, whereas aloft Wing-flashes were only about 10 per cent of the adult total. Probably the begging-calls of the young aloft more often called my attention to their Wing-flashing than did any factor of the adults' behavior aloft. All the Wing-flashes of young birds aloft were followed by begging (5/5, $P = < .002$ by exact binomial).

TABLE 5

WING-FLASHING BY FLEDGED YOUNG PERCHED ALOFT IN 1958

Wing hitches	Behavior following Wing-flash	
	beg[1]	other
1	9	0

[1] All birds gave begging-call. Adult bird within 5 feet of young in every case.

DISCUSSION

To state that Wing-flashing is definitely used in foraging is the conclusion of this paper but not the end of the problem. The exact mechanism by which Wing-flashing is utilized is still in doubt, for instance, and how the behavior develops is still unknown.

An inference from this study is that Wing-flashing frightens insects into betraying themselves (see Hailman, 1960*b*, for other evidence), and therefore increases foraging efficiency of the Mockingbird. But even if this were true, does Wing-flashing flush insects by casting a shadow over them, or by reflecting light upon them, or by some other mechanism? Allen (1947) suggested the white under-wings reflected light into the grass; if so, does this actually frighten insects, or does it just enable the bird to see them better? I am continuing observations on this problem.

My observations on young birds show that the actual motor pattern of Wing-flashing is developed at fledging, but that "proper" (adult) use of it is not. That is, young birds give Wing-flashing irrelevantly without association with foraging motions, or while begging. Many previous observers have noted that young birds tend to Wing-flash when confronted with strange objects or in strange situations (Michener and Michener, 1935:106; Laskey, *in* Sutton, 1946; Sutton, 1946; J. R. Michener, Laskey, and Brackbill, all in pers. comm.). The connection of Wing-flashing and begging (also mentioned by Sutton, 1946) suggests that internal hunger stimuli may contribute to the motivation of this behavior in young birds. These facts suggest that young birds capable of performing the motions early in life learn how to use them later, perhaps when insects jump or twitch before them.

The phylogenetic origin of the wing motions is unknown. Sutton (1946) believed Wing-flashing to be a modification (ontogenetic or phylogenetic?) of the wing-fluttering of begging young. In my experience the motions are quite dissimilar, the latter being a loose vibratory motion of the wings while they are held slightly out from the side in contrast to the hitching upward of Wing-flashing; I never saw any intermediate motions. Wing-twitching motions of the Starling (*Sturnus vulgaris*), which are analogously associated

with insect capture, closely resemble wing-flicks of flight intention (Hailman, 1959), but no such similarity exists in the Mockingbird. Although the Mockingbird's behavioral repertoire includes many other wing movements (such as courtship flights, "wing-flickering," Spread-display, etc.), none resembles Wing-flashing closely enough to suggest common origin.

Previous Reports of Wing-flashing

The many previous reports of Wing-flashing in the literature have generated a number of hypotheses and disagreements about the behavior. The variation in actual form of Wing-flashing should now be settled (above, and Wampole, 1949; Tomkins, 1950; Brackbill, 1951). Many authors have concluded from their observations that the function of Wing-flashing is foraging; others who have not stated this conclusion, nevertheless have included information in their reports which indicates that it is true (e.g., Michener and Michener, 1935:106, 111, 118; Sutton, 1946; Sprunt, *in* Bent, 1948:307–308; Tomkins, 1950; Whitaker, 1957). Only two references I have seen do not mention foraging: Forbush's (1929:320) early account casually refers to this behavior as "courtship," and Hicks (1955) called a predator reaction "wing-flashing," although the actual form of the behavior observed is not described.

Recently, Selander and Hunter (1960) have shown that Mockingbirds use a Wing-flashing-like behavior when mobbing owls or dummies, and possibly in intraspecific hostile encounters. I suggested to Selander that this pattern might be different from, but very similar to, true Wing-flashing. However, he has seen the motions in the foraging context described here, and is "convinced that the wing motions do not differ" (pers. comm.).

Nevertheless, I believe that many of the conclusions in the papers which assign a function other than foraging to Wing-flashing can be explained by four factors: (1) observations were of young birds, in which the foraging connection is not yet made; (2) behavior observed was not Wing-flashing, but may have been one of the other numerous wing motions of the Mockingbird (male wing-droop display, vertical and swoop song-flights, female precopulatory wing-quivering posture, young begging posture, etc.); (3) the entire behavioral situation was not observed (*i.e.*, there were other motivating factors present, such as young, which distracted the Mockingbird's attention from feeding); and (4) single observations may have been of the rare cases in which Wing-flashing is not connected directly with foraging (see Tables 1–3).

Wing-flashing in Other Species

In Mimidae.—Several other species of the family Mimidae use apparently homologous motions. Halle (1948) observed Wing-flashing in the Calandria

Mockingbird (*Mimus saturninus*), as well as in *polyglottos*, and noted that the former was "doing the same thing in the same way" as the latter. Another member of the genus, the Graceful Mockingbird (*M. gilvus*), Wing-flashed while foraging (Haverschmidt, 1953), using apparently similar movements; in fact, it is a quite common habit of this species (Haverschmidt, pers. comm.). Whitaker (1957:361) also observed this species giving the "same jerky movements used by *polyglottos*" while foraging. Neither *saturninus* nor *gilvus* has wing patches. Laskey (*in* Sutton, 1946:208) "observed an adult Brown Thrasher (*Toxostoma rufum*) opening and closing its wings while investigating something . . . where it had been hunting food." Tomkins (1950) also reports having seen this species ". . . flash its wings in identical fashion" to the common Mockingbird. Thomas (Whitaker, 1957) has apparently observed Wing-flashing by the Brown Thrasher many times.

Wing motions of the Blue Mockingbird (*Melanotis hypoleucus*), seen by Skutch (Whitaker, 1957:362), and of the Catbird (*Dumetella carolinensis*), mentioned by Vaurie (1957:309–310), may bear some relation to true Wing-flashing, but no good description of their physical form is yet available, and they do not appear to occur in a foraging context (at least from preliminary descriptions), as do the Wing-flashing motions of the species mentioned above.

In non-Mimidae.—It is obvious that merely because motions are termed "wing-flashing" it does not make them either homologous or analogous to Wing-flashing of the Mockingbird; such behavior has previously been discussed and cited (Whitaker, 1957; Hailman, 1959). However, many species of non-mimids do possess analogous wing-movements which are used in foraging, apparently to flush prey. Sutton (1946) mentioned such motions of the Roadrunner (*Geococcyx californianus*) and the Least Bittern (*Ixobrychus exilis*). Whitaker (1957) cited accounts of wing movements in foraging African herons. To these could be added the Starling's (*Sturnus vulgaris*) "wing-twitching" used in insect capture (Hailman, 1959) and two kinds of wing movements by the Louisiana Heron (*Hydranassa tricolor*) during foraging (Hailman, 1960*c*). I think it is significant that of the Galapagos finches, only the insect-eating "*Certhidea* repeatedly flicks the wings partly open when hopping about the bushes," while the seed- and fruit-eating forms do not do this (Lack, 1947:146).

Conclusions

From my own observations and from the reports of others, the following conclusions about Wing-flashing may be formulated: (1) In adults, it is definitely a foraging motion, but it is possibly also used in predator displays; (2) In young birds the connection with foraging is not as great; factors of hunger, fear and curiosity seem instrumental in eliciting the behavior. The

major problems concerning Wing-flashing now seem to be: (a) exactly how is the behavior used in foraging; (b) what is the exact role of Wing-flashing in inter- and intraspecific hostile situations; and (c) how does the behavior develop?

Summary

The Mockingbird (*Mimus polyglottos*) lifts its wings in jerky motions termed Wing-flashing. The number of "hitches" in which the wings are spread varies between one and five, and the direction of spread varies from nearly horizontal to nearly vertical. Wing-flashing is not used as a display to other birds. The behavior following 83 Wing-flashes of adults on the ground in 1958 consisted of one of three foraging motions: running, looking down, and striking, except for three observations. Likewise, 1959 data showed 256 of 258 Wing-flashes followed by foraging. All of the nine Wing-flashes given aloft were followed by foraging.

Fledged young on the ground followed Wing-flashing by 21 foraging motions and five begging postures; six Wing-flashes were given irrelevantly. Aloft, all of the nine were followed by begging.

Previous reports on functions of Wing-flashing differ in conclusions, but upon re-examination all indicate that foraging was probably the principal factor involved; probable causes of other conclusions are discussed. Apparently homologous motions are used in other Mimidae species for foraging, and many unrelated species use various forms of wing motions in foraging.

In adults, then, Wing-flashing is used in foraging, possibly to flush insects; but in young birds it is often given irrelevantly, and seems to be motivated by hunger and curiosity.

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