

was administered by the newly arrived parent while the bird that tended the nest in the daytime gave the first evening *poor-will* call and seemed to assume the task of securing food for its mate. Although not observed, it seemed probable that the latter transferred food to the young. When one or both parents were disturbed at the nest at night, a soft alarm note was uttered and the intruder, upon departing, was followed for a distance of several hundred feet. In no instance was either of the parents seen to fly directly to the nest. The last few feet were accomplished on foot by means of a waddling walk. When the bird was returning in the daytime after being disturbed, the approach on foot was very slow. After dark it was made more rapidly and the distance traversed on the ground was frequently less. On one occasion all but the last five feet were covered by short hops. The white throat patch was seen to be displayed by at least one of the adults. The exact significance of this display is not known but it could have been for purposes of recognition. No attempt was made to distinguish the sexes of the adults.

*California Academy of Sciences*  
*San Francisco, California*  
*October 25, 1946*

---

## THE FLIGHT OF SWALLOWS

BY CHARLES H. BLAKE

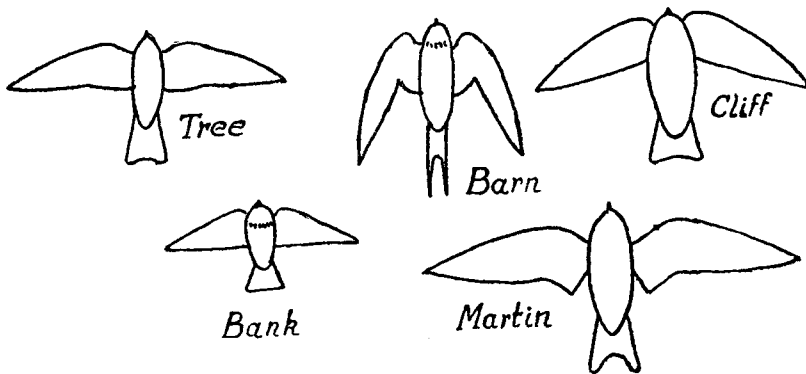
It has long been known that each of our swallows has its own distinctive manner of flight. The best comparative descriptions I have found (Chapman, 1932, and Bent, 1942) give rather correct impressions but are a bit lacking in circumstantiality. In these notes I attempt to put down the rate of wing flapping during coursing (the ordinary feeding sweeps), the duration and attitude of gliding, and the usual geometry of the feeding maneuvers for the six northeastern swallows. For part of the species I have data on other styles of flight. The method of measurement and the definitions of terms will be found in a previous note (Blake, 1947: 619-620). The figures of the gliding attitudes (Text-figure 1) are simply diagrams, not to scale and not pretending to any artistic merits.

I hope the material given here may serve as a stimulus, not only to further investigation in the swallows but in other families as well.

**TREE SWALLOW, *Iridoprocne bicolor*.**—The flight of the Tree Swallow is especially marked by its custom of sailing in rather small circles, 20 to 100 feet or more in diameter (*cf.* Chapman, 1932: 383). The

glides are somewhat interrupted by single wing flaps which I call trimming flaps, since their purpose seems to be to reset the wings after a change of course relative to the wind. The end of a glide is often marked by a short, sharp climb made by a few (usually but three to five) quick flaps. I have not, however, found really characteristic the pattern of flight described by Hoffman (1927: 215) in which the bird rises and then drops at the end of a glide. Perhaps this is more characteristic of migration. There are certainly differences in some species of swallow between the flight of migrants and that of birds on their breeding grounds.

A glide, including trimming flaps, usually lasts from five to ten seconds even though much longer glides (32 and 34 seconds) have been



TEXT-FIGURE 1.—Gliding attitudes of swallows.

observed. When gliding the wings are widely spread and sensibly horizontal. Naturally this attitude is subject to variations, such as a partial folding of the wings when losing altitude. Some trimming is accomplished by basal torsion of the tail. My sketch of the gliding bird, worked out early in the breeding period of a resident pair, shows an indication of the notch referred to by Nichols (1920: 281) but not as distinctly as one made three weeks or so later would have done. It is possible that the wing molt which begins at that point may be started in early July and hence sometimes before completion of nesting. On this point there is the alternative that wear may be the cause. In a pair still feeding young, the female which is brown-backed, presumably just over a year old, shows little of the notch and her wings appear in good condition. Her mate shows a distinct notch (mid-July) and his wings are noticeably ragged.

I have 25 observations put down in my notes as coursing which

show a rather random distribution of flapping rates from 2.5 to 4.5 per second. These seem to represent one style of flight, although some almost certainly are from a bird sailing about its nest but not entering because of my presence. In any event, the observations are of about the same degree of consistency (standard deviation of about 20 per cent) as my other sets of swallow observations, which have definite modality. The average of the 25 observations is  $3.5 \pm 0.69$  strokes per second.

A long, slow climb is made with the usual fairly deep strokes and is not distinguishable from coursing. Six observations of short, sharp climbs yield  $4.7 \pm 1.0$  as an average and the greatest rate noticed is 6.2 strokes per second. Two observations of long, steady flight average 3.7 or not different from coursing.

Tyler (*in* Bent, 1942: 393) compares the flight of Tree and Barn Swallows. The apparent unsteadiness of the former in the air I interpret as a consequence of lower speed and more frequent changes of direction. However, I have not found sailing with lowered wing tips to be any more characteristic of Tree Swallows than of other swallows.

A final point to which I have given some attention is overspreading of the tail to the extent that its terminal margin becomes convex. The Tree Swallow does this occasionally in making a very sharp turn.

**BANK SWALLOW, *Riparia riparia riparia*.**—The fluttery, almost butterfly-like stroking of the Bank Swallow is its outstanding characteristic. That this is so only reflects the relatively small rôle played by gliding in its aerial maneuvers. The species does glide but its glides are very short and unstable, mostly lasting two seconds or less and ending with a few quick strokes. The wings are held horizontal or may droop just below the horizontal. Basal torsion of the tail is quite frequent and the tail is usually so spread that the terminal margin appears straight. The whole course covered by this species in feeding is very irregular, differing strongly from the almost predictable courses of Tree and Barn Swallows.

The attitude of the wings in gliding is rather distinctive, with the carpal joint far forward and close against the head, the trailing edge of the wings straight and transverse.

Twenty-four observations of flapping rates can be divided into two groups. The first contains 14 observations on the ordinary coursing which show an average of  $2.8 \pm 0.14$ , the extremes being 2.6 and 3.1. The second group (10 observations) shows the higher rate used in climbing or on recovery after a glide. Its average is  $3.7 \pm 0.36$  with extremes of 3.1 and 4.5. The difference between these two groups is

significant. It is worth noting that each group is more consistent than I have usually found in swallows. At the end of a stroke the wings are bent well back but the forward (so-called recovery) stroke starts at once, with the bird not gliding in the terminal position.

My observations agree well with the main points mentioned by previous writers—the fluttering motions, irregular course, and absence of conspicuous glides. The reason for the relatively low flapping rates will be taken up later.

ROUGH-WINGED SWALLOW, *Stelgidopteryx ruficollis serripennis*.—I have had only one pair of this species under considerable observation and have not been able to satisfy myself as to some details. The flight is not, in my opinion, very closely related to that of the Bank Swallow. Migrating birds bear a marked resemblance in action to Barn Swallows, with the wings folded well back at the end of the stroke and changes of course rather infrequent. Doubtless, this is what Lynds Jones (1912: 177) had in mind in speaking of its apparent reserves of power.

The geometry of the feeding flights is not known to me in much detail but seems to comprise fairly long runs between turns, somewhat as in Barn or Cliff Swallows. What appeared to be a family party, with the young about two weeks out of the nest, was watched feeding over a small pond. The relatively long runs and short glides, as well as the wing motion, suggested the Barn Swallow. On the other hand, the slower flapping and the very marked climbs at the end of the runs were much more like the Cliff Swallow. Chapman (1932: 384) is correct in speaking of the flight as less erratic than that of the Bank Swallow, but without measurements my impression is of greater, not less, speed. The slow flight noted below is an exception. A rather similar statement is made by Forbush (1929: 162). The species may also, if disturbed near the nest, fly in circles with rather frequent but short glides. Under these conditions the usual glide lasts four to five seconds, although one was timed at 25 seconds. Even the trimming flaps end with the wings pulled well back. The normal glide position is almost as in the Tree Swallow but the wings appear a trifle wider at the base.

The styles of flight in the Rough-wing proved surprisingly diverse. Nine observations of coursing gave an average of  $3.3 \pm 0.47$  strokes per second, the next to slowest rate of the six species studied. For the quick flapping, as used in climbing, I have six observations which average  $3.9 \pm 0.66$ ; the extremes here are 2.9 and 4.4. In addition to these two styles, which are to be expected in most swallows, the Rough-wing uses two slow styles. Three observations of slow, steady

flapping all gave a rate of 3.2 per second. Finally, three observations of flap and glide flight (Blake, 1947: 620) while not too uniform were all rather slow and averaged 2.8.

This diversity of styles of flight only accentuates the rather numerous ways in which this species diverges from our other swallows. The most that can be said is that it shows some resemblance in flight to the Barn and Cliff Swallows but none at all to the Bank Swallow. If all its characteristics of behavior and structure are taken together, it seems quite unrelated to other North American swallows. See, however, Miller's (1947: 370) interesting remarks on *S. r. aequalis* in Colombia.

BARN SWALLOW, *Hirundo rustica erythrogaster*.—Those not familiar with the Rough-winged Swallow would say that the Barn Swallow in flight can scarcely be compared to our other swallows. Its aspect in flight is, in fact, very distinctive, but this is due to three causes, only one of which seems to be related to its manner of flight. These causes are the long tail, the gliding attitude, and its preference for coursing very close to ground or water.

Of this species it is fair to say that it courses in long runs which average roughly straight and seem often repeated. It is quite usual to see a bird reach the margin of a field and turn sharply back on its previous path. One may make not too bad predictions about what Barn Swallows will do. Even a quite small obstruction will often turn them back. This may be no more than the rank, unmown weeds along a drainage ditch. If one flies low along a certain stretch of road, as is common early in the season, then, in a few moments, the same or another passes that way. These long runs include frequent slight changes of course to right or left which tend to cancel one another. However, every so often, a bird gives within a small space an exhibition of stunt flying, with sharp turns, zooms, and dives that surpasses anything I have seen in other swallows. The Barn Swallow departs from this pattern when feeding over some special source of food, a group of cattle, or a strolling ornithologist; the general course becomes as circular as that of the Tree Swallow but held nearer the ground and at higher speed. Perhaps here, better than under other conditions, one feels the justice of Tyler's (*in Bent*, 1942: 392–393) emphasis on the strong drive of this species through the air. Chapman (1932: 385) compresses his account into too small a compass by speaking of all the patterns of flight in one breath.

This feeling of drive is accentuated by the relative rarity and the brevity of glides. The Barn Swallow, even when gliding, pulls the wing tips well back, which removes any hint of rest or calmness. Glides last mostly one to two seconds and infrequently three seconds.

The Barn Swallow seems to possess but two styles of flight—coursing and quick flapping. The former shows some departure from uniformity. The early, prebreeding observations average well below the general average of the 40 observations I consider to be coursing. The whole range is from 2.9 to 5.7 with an average of  $3.9 \pm 0.69$ . Omission of the one observation of 5.7, which may be wrongly assigned, would not change the average and would only reduce the standard deviation to 0.63. I have but three observations of quick flapping which were made during favorable examples of stunt-flying. These average 5.2.

As is well known the tail is carried nearly closed except when turning or braking for a landing.

Qualitative observations do not convince me that the actual speed of the Barn Swallow is much greater than that of other swallows, but its more straightaway flight gets it over the ground a good deal faster.

NORTHERN CLIFF SWALLOW, *Petrochelidon albifrons albifrons*.—In spring a Cliff Swallow may be picked from a flock of migrants by its pattern of flight. At fairly frequent intervals the bird climbs steeply on rapidly beating wings, not a mere five or six feet as others do but usually fifteen to thirty feet and perhaps more. Reaching the top of its ascent it may dive to the starting level or more often flutter downward. This pattern is maintained in a less extreme form throughout the season. The climbs are less high and more frequent; the bird appears to be riding an invisible roller coaster. When a Cliff Swallow and a Barn Swallow cross a pond on parallel courses, the difference of pattern is very striking. The latter exceeds the former in speed by about the proportion of the extra climbing of the Cliff Swallow. Evidently Hoffman (1927: 213) refers to this habit although I do not agree that there is any great risk of confusing the Cliff and the Tree Swallows on this head. The geometry of feeding flight is perhaps best described as a series of long ellipses—that is, intermediate between the Tree and the Barn Swallows.

The Cliff Swallow employs short and frequent glides which last, for the most part, two to three seconds, with one of 10 seconds recorded. The wings are held in an attitude intermediate between the attitudes of the Tree and the Barn Swallows. This is the only species which seems customarily to slant the wings downward when gliding.

Flapping rates for the Cliff Swallow are similar to those of the Barn Swallow. Ten observations of coursing show a spread from 2.9 to 4.5 flaps per second with more than half the observations in the upper half of this range. The average is  $3.9 \pm 0.55$ . There is also a quicker flapping used both for climbing and for turns. Seven observations of

this average  $4.6 \pm 0.41$ . The highest rate noted was 5.8 by an adult that had just left the nest. This is not included in the quick flapping series.

Especially on turns the tail is overspread showing a convex terminal margin. The Cliff Swallow does this more than the Tree Swallow but less than the Purple Martin.

PURPLE MARTIN, *Progne subis subis*.—My acquaintance with this species is limited to breeding birds, so I cannot say whether its manner of flight differs on migration or about its roosts from that described here. The account given by Sprunt (*in Bent*, 1942: 498–499) does not indicate any radical difference with season or special activity.

The pattern of flight, as I have seen it, is very uniform and at first sight quite identical with that of the Tree Swallow. Since the differences are almost wholly quantitative there is a likelihood of confusing these two species at a great distance. The martin sails in circles estimated to be mostly thirty to sixty feet across, with a rather regular alternation between quick flapping and gliding. The glides are mostly rather short, less than seven seconds, with the majority lasting three to four seconds. I have a record of a bird high in the air gliding for 26 seconds almost without the interposition of trimming flaps. The wings are horizontal in gliding. Changes of altitude tend to be slow. This may be summed up by saying the martin has plenty of power and speed but less maneuverability than the smaller swallows. In this connection the present species seems to employ the tail more vigorously than the other species. Basal torsion is so frequent as to be almost a definite characteristic. In a sharp curve or on landing, the tail is overspread so the terminal margin is convex. This happens so frequently and the pose is held so long it does not have to be watched for to be seen. Even in the Cliff Swallow, overspreading must be specially looked for.

In this species there is some doubt whether there is any real difference between coursing and the quick flapping used in climbing. Certainly the difference is small. I have noted four observations as coursing, and these average 3.8 flaps per second. The eighteen observations designated as quick flapping average  $4.4 \pm 0.51$ . Even if the standard deviation of each set were as little as 10 per cent of the average, the difference between them would be of quite doubtful significance. On the whole, I prefer to put the 22 observations together with an average of  $4.4 \pm 0.57$  and extremes of 3.3 and 5.6. The martin, then, can be said to have but a single style of flight.

## DISCUSSION AND SUMMARY

It will be readily seen that there are three main patterns of flight—circles, long, straightish runs, and zigzagging. The choice of a pattern seems to be behavioral or psychological. Only in the case of the Bank Swallow does maneuverability appear to be a factor. A similar situation can be seen in the variable duration of glides. Each species is capable of gliding much longer than it usually does. Only the Barn Swallow, which glides in an attitude of reduced lift, can be said to be physically limited to brief glides, but here again the attitude chosen is a consequence of behavior, not of physical necessity. This may be pointed up by the case of the Chimney Swift which is said to have but two wing positions—fully open and fully closed; hence, if it is to glide at all, it must use the fully open position.

Turning to the wing-flapping rates, only in the Rough-winged Swallow was it possible to detect any styles of flight other than coursing and quick flapping. The point which seems at first sight odd is that the wing-flapping rates for coursing increase with increasing size of the species. We notice as premises: (1) The wing-loading (recalculated from Poole, 1938: 514, 515) increases a little with increase in linear dimensions—Barn, Rough-wing, Tree, 0.3 lb. per sq. ft.; Purple Martin, 0.5 lb. per sq. ft. This increase hardly affects the power required for maintenance of steady speed. It does increase the power needed for acceleration. (2) The speed of cruising does not diminish, and probably increases, with increasing size of the bird, and the power required increases at least as the square of the linear dimensions. (3) We assume as a first approximation that the wings are essentially a propeller on a horizontal shaft and that the increase in the size of the propeller is not in proportion to the increased power requirement. Then, each of these three premises, in varying degree, leads to an increase in wing rate for increase in size.

The difference in rate between coursing and quick flapping corresponds in a general way to the difference in maneuverability, although this point cannot be pushed too far. In any event, the difference is greatest for the Barn Swallow and nearly as great for the Tree Swallow, and least for the Rough-wing and the Purple Martin. It may be significant that the last species seems most dependent on the tail in maneuvering.

## LITERATURE CITED

BENT, A. C.

1942. Life histories of North American flycatchers, larks, swallows, and their allies. U. S. Nat. Mus., Bull. 179: i-xi, 1-555, 70 pl.

BLAKE, C. H.

1947. Wing flapping rates of birds. *Auk*, 64: 619-620.



CHAPMAN, F. M.

1932. Handbook of birds of eastern North America. 2nd rev. ed. (New York and London.)

FORBUSH, E. H.

1929. Birds of Massachusetts and other New England States. 3. (Boston.)

HOFFMAN, RALPH

1927. Birds of the Pacific States. (Boston and New York.)

JONES, LYNDIS

1912. A study of the avi-fauna of the Lake Erie islands. *Wilson Bull.*, 24: 171-186.

MILLER, A. H.

1947. The tropical avifauna of the upper Magdalena Valley, Colombia. *Auk*, 64: 351-381, 2 pl.

NICHOLS, J. T.

1920. The Tree Swallow on Long Island. *Bird-Lore*, 22: 279-281.

POOLE, E. L.

1938. Weights and wing areas in North American birds. *Auk*, 55: 511-517.

*Massachusetts Institute of Technology*  
*Cambridge, Massachusetts*

## THE DISCOVERY OF THE HABITAT OF GOULD'S HUMMINGBIRD, *HYLONYMPHA MACROCERCA*

BY WILLIAM H. PHELPS AND WILLIAM H. PHELPS, JR.

THIS species and monotypic genus were described by Gould (1873: 429) from a trade-skin obtained on the London docks from a lot containing others of the species. Later in the same year a large lot of skins of the same species was received in London, but since then no known records have come to light and the habitat of this large, striking, long-forked-tailed hummingbird has always been an enigma. Elliot (1878: 97) gives the habitat as "Northern Brazil." Salvin (1892: 326) says, regarding the range: "Uncertain; said to be the Amazon Valley near the middle."

Boucard (1893-1895: 284) describes the finding of the type specimen as follows: "A good number of specimens of this remarkable species were offered for sale in 1873 at the London docks. Another lot came shortly after. No more has come since. The typical specimen was a poor skin. It was secured by Mr. H. Whitely and sold by him to John Gould. I remember as if it were yesterday, and the excitement it caused to him. At that time I was living at Great Russell Street. He brought it to me at once, and I could scarcely believe that it was a real species. We thought at first that it was a tail of something else stuck into the body of a *Chalybura*, but after a careful examination we agreed that it was a new and remarkable genus. I have never been