FORAGING BEHAVIOR OF MANGROVE SWALLOWS AT BARRO COLORADO ISLAND

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DURING January through July 1968 I had the opportunity to make incidental studies on a pair of Mangrove Swallows (*Iridoprocne albilinea*) breeding in a nest box on the boathouse of the Smithsonian Tropical Research Institute at Barro Colorado Island (BCI) in the Panama Canal Zone. Although the Mangrove Swallow is common along the shores of Gatun Lake, it has received little attention. The species is particularly relevant to several ecological problems because it is active in open habitats where it is easily watched, and because it has a close northern counterpart, the Tree Swallow (*Iridoprocne bicolor*). With limited time, I concentrated on nestling development and care of the young after fledging (to be described elsewhere) and adult foraging behavior during the nestling period. Observations demonstrated complex patterns of territory utilization and diurnal activity, which are summarized and interpreted here. Although this report is based on limited study of a single pair of birds, it points up several aspects of the use of time and space by birds that deserve more attention from ornithologists.

GENERAL BIOLOGY

The Mangrove Swallow is a rather small member (13–16 g) of the *Tachycineta-Iridoprocne* group, which includes the Tree Swallow and Violet-green Swallow (*Tachycineta thalassina*) in temperate regions and several tropical species, notably *T. albiventer* in northern South America and *T. leucorrhoa* and *T. leucopyga* to the south (Mayr and Greenway, 1960). Three subspecies of *T. albilinea* are recognized, ranging along the coasts of Central America from Sonora and Tamaulipas, Mexico, south through Panama on both sides of the Isthmus, and in Northwestern Peru. Canal Zone birds belong to the nominate race.

Mangrove Swallows are restricted to lowlands including Gatun Lake in the Canal Zone. Like other members of the family, the Mangrove Swallow feeds aerially, usually close over lakes, larger rivers, and bays, but may forage 100 feet or more above the water surface. Occasionally it forages over open marshes or extensive meadows.

Mangrove Swallows eat small flying insects. Henry Hespenheide analyzed the stomach contents of two individuals collected 8 July 1968 in Guanacaste Province, Costa Rica: one contained 370 flying ants, 55

TABLE 1

SEASONAL DISTRIBUTION OF CLIMATIC DATA IN THE CANAL ZONE[1]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean monthly rainfall (mm), BCI	56	33	30	89	274	274	284	318	262	358	462	279
Windspeed (km/hr), G	12	13	13	12	9	7	7	8	8	8	9	10
Daylength (hrs:min) 21st of month												
10° N	11:39	11:52	12:07	12:24	12:37	12:43	12:37	12:24	12:08	11:51	11:38	11:32
40° N	09:49	10:58	12:11	13:30	14:34	15:01	14:36	13:32	12:13	10:55	09:48	09:20
Change in daylength (sec/day)												
10° N	14	26	30	34	26	12	12	14	32	34	26	12
40° N	58	138	146	158	128	54	50	128	158	156	114	56
Daily solar radiation at surface ($gcals/cm^2/day$)[2]												
Canal Zone	425	425	450	350	300	250	350	300	350	350	350	375
Philadelphia	150	225	325	425	475	500	475	450	375	274	200	150

[1] Weather data from Panama Canal Company, Meteorological and Hydrographic Branch; daylength data from List (1966); solar radiation from Black (1956). BCI = Barro Colorado Island; G = Gatun, on the Caribbean side of the isthmus. Average temperature remains very constant throughout the year, averaging 30°C. Mean minimum relative humidity is about 60 per cent during the dry season months and 75 per cent during the rest of the year at Barro Colorado Island.

[2] Approximate values taken from world maps.

other hymenoptera, 11 beetles, and 2 hemiptera; the second contained 13 homoptera, 10 flying ants, 7 other hymenoptera, 2 beetles, and 1 diptera.

Breeding

In Panama breeding appears to be restricted to the dry season and early part of the wet season. Meager data suggest that laying occurs from January through April and that young may be fed through July. Non-breeding Mangrove Swallows usually forage low over the water in small groups, four or five to several dozen, and are often seen perched on small branches jutting from the water or on telephone wires. The onset of the breeding season is marked by the breakup of flocks and presumably coincides with the establishment of nesting sites by the adults. When I left the Canal Zone for a brief trip during the third week of December 1967, swallows were still in flocks, and the rainy season had not yet ended. Between that time and my return to BCI 15 January, the rains had ceased, skies had cleared, and the dry season winds had picked up. Swallows were no longer foraging in groups, and could be found only in pairs around the edge of Gatun Lake. One pair had occupied a nest box put up during the previous year on the boathouse on BCI and was carrying nesting material to it. The first egg was laid on 19 January. The rapid change in behavior of the Mangrove Swallow at a time when changes in day length are negligible (Table 1) suggests that the swallows respond to some aspect of the abrupt wet-dry season change in the Canal Zone area. Cloud cover, rainfall, relative humidity, wind velocity, foliage density in the forest canopy, and tree flowering among other environmental features could be proximate factors triggering the onset of breeding activity.

The first flocking of swallows after the breeding season in 1968 was noted on 28 May, about 3 weeks after the young of the second brood at BCI fledged. Thus, the total length of the breeding season was about 5 months.

Feeding conditions evidently improved during the course of the breeding season, although samples from a trap for flying insects in a nearby clearing did not change appreciably during this period. In February the pair was able to fledge only one of three young in its first brood, but fledged three of the second brood, raised in April and May. Growth curves for these broods (Ricklefs, MS) showed undernourishment in the first brood but not in the second.

The activities of the pair of Mangrove Swallows at the boathouse ranged over and on the periphery of a protected bay of Gatun Lake (Figure 1). The bay is surrounded by tall forest, except between feeding areas A and

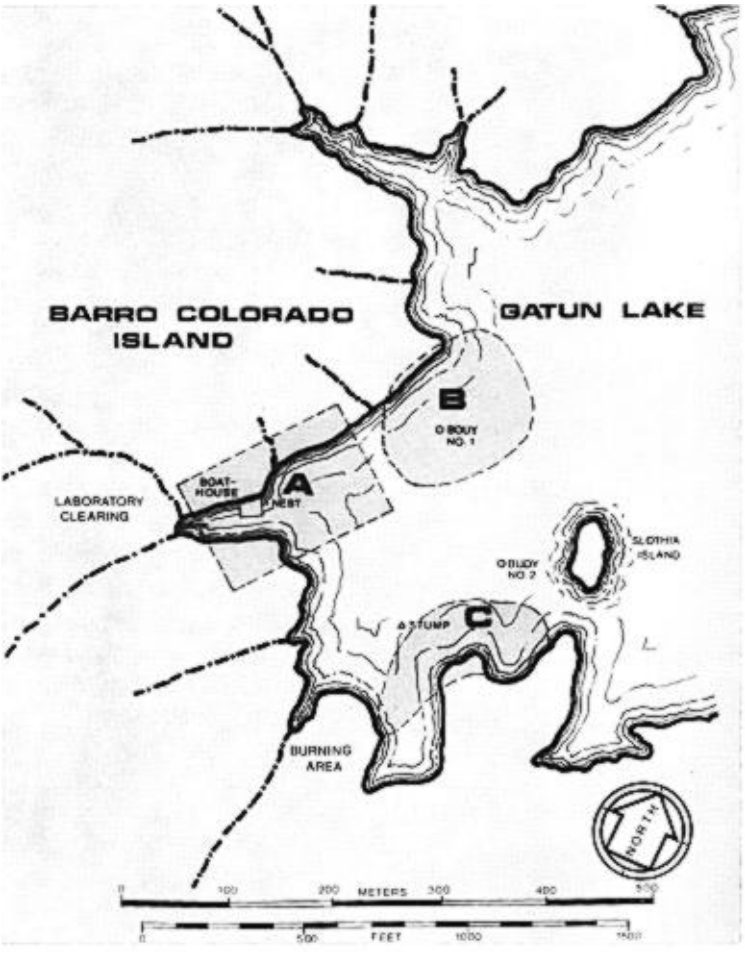

Figure 1. Map of the area of Barro Colorado Island and Gatun Lake showing the foraging localities of the pair of Mangrove Swallows that nested at the boathouse. Most of the feeding occurred in areas A, B, and C. Observations were made from the edge of the lake, about 30 m north of the nest.

B, where a clearing with second growth vegetation up to 5 m tall extends back about 100 m from the shore. The swallows perched frequently on two buoys and a stump in the middle of the bay, and also occasionally on the corrugated aluminum roofs of the boathouse and a small storage shed, and on some branches protruding from water in the area used for burning trash. The most intensive foraging areas were assigned letters and are indicated on Figure 1 by shading, but the birds fed over the entire

Figure 2. Foraging positions of the adult Mangrove Swallows at 5–10 second intervals for a 12-minute period on the morning of 18 February 1969 in area A. The black circles represent feeding at heights greater than 50 feet, the lightest circles at heights less than 3 feet.

area at times. The size of the activity area, about 500 m square, was such that the swallows could fly across it anywhere in 10–20 seconds.

Feeding the Young

Because the Mangrove Swallows foraged in the open, I could record simultaneously both the number of trips to the nest and the feeding activities of the adults. From one vantage point near the boathouse all of the swallows' feeding areas were visible except a portion of area B. I made observations during ½-hour periods spaced at regular intervals when the young of the first brood were 13, 14, and 18 days old, and when the young of the second brood were 4 and 13 days old. Two young remained in the first brood on the 13th and 14th days. The loss of weight by one nestling suggested that the brood was poorly nourished. On the 18th day only one young was still alive, and though it was losing weight at this time, recession of weight is normal for older nestling swallows (Ricklefs, 1968) and its weight was greater than that of adults. The second brood contained three well-nourished young during the entire nest period. On the 4th day energy requirements of the young would have been low owing to their small size. I also watched the swallows during the egg period of the second brood.

TABLE 2
FORAGING BEHAVIOR OF ADULT MANGROVE SWALLOWS ON BARROW COLORADO ISLAND FEBRUARY 1968

Time of observation	Number of feedings	Time spent flying (per cent)	Time spent out of nest area (per cent)
18 February[1]			
06:30–07:00	28	94.8	5.0
08:30–09:00	7	53.9	11.8
10:30–11:00	8	29.4	46.7
12:30–13:00	17	42.4	12.3
14:30–15:00	6	34.1	75.6
16:30–17:00	1	86.7	28.1
19 February[1]			
06:40–07:00	11	93.8	19.0
07:30–08:00	12	46.2	17.4
09:30–10:00	10	47.3	41.5
11:30–12:00	15	53.1	14.1
13:30–14:00	8	56.6	20.0
15:30–16:00	3	80.9	51.2
17:30–18:00	10	79.7	5.0
23 February[2]			
06:30–07:00	7	91.8	24.1
07:30–08:00	4	33.7	16.7
08:30–09:00	12	37.5	18.0
09:30–10:00	10	65.9	49.4
10:30–11:00	1	15.0	13.3
11:30–12:00	7	33.6	1.3
12:30–13:00	9	52.1	9.0
13:30–14:00	8	38.5	8.7
14:30–15:00	7	45.5	4.1
15:30–16:00	5	47.9	0.8
16:30–17:00	7	35.3	4.7
17:30–18:00	4	67.8	13.7

[1] Two nestlings 13 and 14 days old.
[2] One nestling 18 days old.

Adult swallows used two distinct foraging patterns while feeding young in the nest box. The first consisted of foraging within the immediate vicinity of the nest, usually within 100 m and rarely beyond 150 m, roughly area A on Figure 1. The young were fed frequently during these periods of activity. During one period the positions of the adults were recorded every 5 to 10 seconds for 12 minutes (07:10–07:22) on the morning of 18 February, the 13th day of the nestling period (Figure 2). At this time, most of the foraging occurred 5–15 m above the water, and a large portion of the activity centered about the small inlet around the dock and boathouse. At other times the feeding pattern extended farther out towards the bay in front of the boathouse, closer to the water surface, or perhaps over the trees at the edge of the water.

The adult swallows spent periods varying from as few as 1–2 minutes

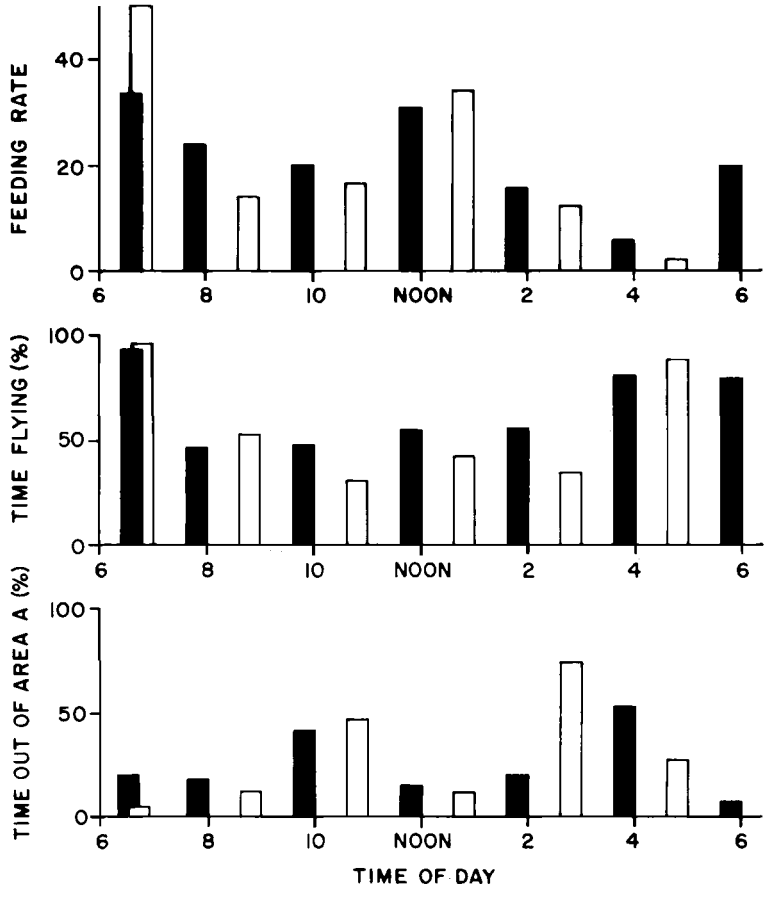

Figure 3. Foraging characteristics of the pair of Mangrove Swallows on 18 and 19 February when two well-grown nestlings were present.

to as many as 5–7 minutes foraging more than 200 m from the nest, most frequently in feeding area B. During these intervals the young were not fed. Frequently both adults foraged together in this manner, but at times one remained near the nest. The distant feeding grounds were probably used exclusively for adult feeding, while areas near the nest were exploited for both adult and nestling food. Two circumstances suggested that the adults did not often carry food to the nestlings from feeding area B. First, it was often noted that they delivered single insects to the young; obvious insect-catching movements were immediately followed by visits to the nest box, particularly when the adults sallied for insects from the roof of the

boathouse. Second, when the adults returned from area B, they rarely fed the young before first foraging in area A.

The ½-hour observation periods were divided into 1-minute intervals during which I recorded (a) the amount of time in seconds both birds spent perched on the boathouse roof, or in the nest box, and (b) the total time both birds were beyond area A. Thus the total time spent flying in area A (c) is equal to the total possible bird-seconds minus (a) and (b). The per cent of time spent flying while the birds were in area A is equal to (c) divided by (a + c). At regular intervals during the day I determined dry and wet bulb temperatures with a sling psychrometer, and I obtained an index of the light intensity with a light meter from the reflection off the back of a gray note pad pointed toward the sun. Approximate cloud cover and wind speed were also noted.

Table 2 and Figure 3 present foraging data for 18 and 19 February. At this time the two young were in their 13th and 14th days and one was losing weight, suggesting that the parents were feeding to their maximum capacity. The similarity of the activity patterns for the two days demonstrates that the observations are repeatable. Several points are of interest. First, between 08:00 and 15:00 the amount of time spent flying was considerably depressed. In the early morning and late afternoon, the adults foraged between 80 and 100 per cent of the time, while during the middle of the day, they spent only 30–60 per cent of their time in the air. Second, during two periods, in the midmorning between 10:00 and 11:00, and in the midafternoon between 15:00 and 16:00, they spent more than 40 per cent of each period at some distance from the nest, whereas this normally amounted to less than 20 percent. Third, the rate at which the young were fed exhibited two dips corresponding roughly to the periods the adults were most away from feeding area A. Furthermore the rate of feeding of the young showed a general decrease throughout the day. The diurnal pattern of foraging activity started with a short period of very intense feeding just after dawn, with much food given to the young. A long period of reduced foraging activity continued through the day until about 16:00, during which time the feeding shifted from being predominantly adult-oriented to being young-oriented and then back to being adult-oriented. At about 16:00 the rate of activity increased again, being predominantly adult-oriented until just before dusk when the rate at which the young were fed increased sharply.

On 23 February, when the single remaining young was 18 days old, the adults were providing adequate nourishment for the nestling and it appeared that they were not so pressed to forage as they were 4 days previously. The feeding pattern (Figure 4) differs in several respects. First,

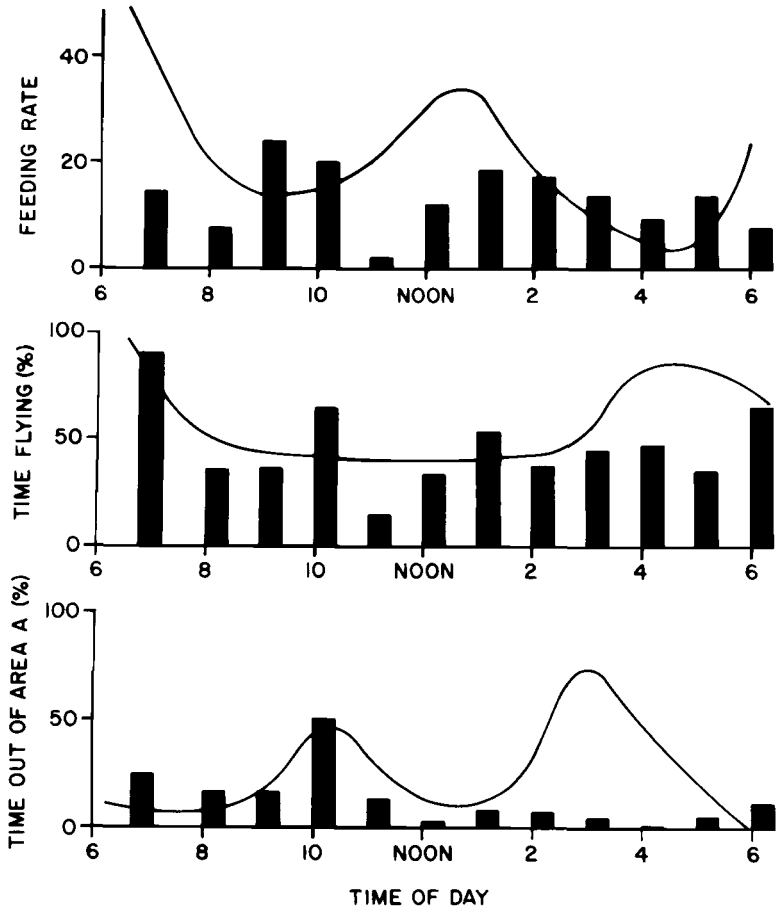

Figure 4. Foraging characteristics of the pair of Mangrove Swallows on 23 February when only one young was left in the nest. The curve follows the trends of foraging behavior on 18 and 19 February.

although the intense early morning activity period persisted, and flying occupied the same proportion of time (45–46 per cent) during the middle of the day, the pair did not show the same increase in activity in the late afternoon except for a slight increase just before dusk. During the day the pair spent only 46 per cent of their time in area A flying, compared to 61 per cent several days earlier. Of the total period, the adults spent 47 per cent perched on the boathouse dock on 23 February, compared to 28 per cent on 18 and 19 February.

Second, the pair made very little use of feeding area B, especially after

TABLE 3
WEATHER AT MANGROVE SWALLOW NEST 18, 19, AND 23 FEBRUARY 1968

Time	Air temperature (°C)			Vapor pressure (mh)			Light reading			Estimated wind (mph)			Sky[1]		
07:00	25½	23	24	1.0	–	0.4	12	40	225	0	–	0	O	C	C
08:00	26¼	26¼	27	1.7	0.8	1.8	40	300	900	0	0–5	0	O	C	C
09:00	26½	27½	28	1.7	1.4	1.8	180	350	1200	0	5–10	0–5	O	P	P
10:00	27	30	29	2.0	2.3	2.7	150	1200	350	5	5–10	0–10	O	P	P
11:00	27¾	29	30	2.5	1.7	3.0	350	350	500	5–10	0–5	5–15	O	O	O
12:00	28	31	31½	2.7	2.7	3.4	500	1200	1100	5–10	5–10	10–15	O	P	P
13:00	29½	32	31	3.2	3.7	3.4	700	1400	1100	5–15	5–10	5–15	P	P	P
14:00	28½	31½	31	2.7	3.4	3.4	800	1000	700	10–15	5–15	5–10	H	H	P
15:00	28¾	30	—	2.7	3.0	–	400	450	–	5–15	5–15	–	H	O	H
16:00	27	28½	31½	2.0	1.7	3.8	200	250	1000	5–10	5–10	0–5	H	O	C
17:00	26¾	27½	28½	1.8	1.0	2.4	60	150	800	0–5	5–10	0–5	H	H	C
18:00	—	26	27	–	0.7	1.8	–	40	25	–	0–5	0	C	C	C

[1] C = clear, H = hazy, P = partly cloudy, O = complete overcast.

11:00. The conspicuous afternoon period away from the nest area on 18 and 19 February was completely absent on the 23 February. In all, the pair spent just 14 per cent of its time out of feeding area A, compared to 28 per cent on the 18th and 19th. Third, the feeding rate was more constant during the day. On the 23rd the single nestling was fed an average of 13.5 ± 7.3 SD times per hour, compared to 20.2 ± 21.5 SD times per hour for the two nestlings on the 18th and 19th. On the 23rd, then, the single nestling was being fed about ⅓ again more often than each of the nestlings was previously. Also the variance in the rate of feeding on the two dates was significantly different ($F = 8.7$; d.f. = 11; 12, $P < 0.01$). The per cent of total time spent flying in feeding area A remained constant between the two dates (44 and 40 per cent, respectively). Moreover on 30 April, when the three nestlings of the second brood were about the same age, the figure was 41 per cent. Weather data for 18, 19 and 23 February taken at the edge of the lake show little change in temperature, a drop in humidity (increase in vapor pressure) during the middle of the day, and a large increase in light readings (Table 3). Estimated wind speed also picked up in the middle of the day.

Three sets of observations of foraging behavior were made when the second brood was 3 days old (Table 4). The feeding rates per individual are relatively lower than for the older nestlings of the first brood. Also, the early morning and late evening counts did not show the intense feeding activity characteristic of adults feeding older young. The time spent flying in feeding area A was low and the time spent out of the nest area was high. The young were brooded for 17, 14½, and 7 minutes (57, 48 and 23 per cent, respectively) of the observation periods.

Nine days later the young were the same age as those of the first brood when the earlier observations were made. The April brood was well-nourished, whereas the February brood was not. The performance of the pair on 30 April was similar to that of 18–19 February in several respects (Table 4). As only five ½-hour periods were recorded it is not possible to compare the observations in detail, but the average rate of feeding and per cent of time flying are fairly similar. Slightly less time was spent perched, and more time was spent out of area A. Also, the per cent of time spent flying was higher at 09:00 (85 per cent) and lower at 17:00 (53 per cent) than would have been expected from the foraging pattern on 18–19 February. In the late afternoon, the per cent of time spent out of area A was quite high and the feeding rate rather low compared to the February figures.

To compare the performance of adults while feeding young and at other times during the nesting cycle, five periods of observation were made on

TABLE 4

FORAGING BEHAVIOR OF ADULT MANGROVE SWALLOWS ON BARRO COLORADO ISLAND APRIL 1968

Time of observation	Number of feedings	Feedings per hour	Time spent in nest area			Time spent out of nest area	
			Perched (sec)	Flying (sec)	(Per cent)	(Sec)	(Per cent)
21 April[1]							
06:05–06:35	10	20	1205 (1020)[2]	1294	51.8	1101	30.6
11:15–11:45	1	2	1280	585	31.4	1735	48.2
17:06–17:36	11	22	775 (420)	733	48.6	2092	58.1
30 April[3]							
06:10–06:40	24	48	70	2995	97.7	535	14.9
09:10–09:40	9	18	200	1128	84.9	2272	63.2
11:15–11:45	9	18	1315	638	32.7	1647	45.8
14:05–14:35	8	16	1170	1300	52.7	1130	31.4
17:20–17:50	3	6	1150	1290	52.9	1160	32.2

[1] Three nestlings 3 days old.

[2] Brooding period in parentheses.

[3] Three nestlings 12 days old.

TABLE 5

FORAGING BEHAVIOR OF ADULT MANGROVE SWALLOWS DURING EARLY EGG PERIOD ON BARRO COLORADO ISLAND MARCH–APRIL 1968

Time of observation	Time spent flying	
	(Sec)	(Per cent)
06:10–06:40	1695	47.1[1]
09:10–09:40	1355	37.7
11:15–11:45	1010	28.1
14:15–14:45	1020	28.4
17:30–18:00	1310	36.4

[1] Based on 3600 seconds time for pair during half-hour period.

31 March and 1 April during the laying and early incubation periods of the second nesting (Table 5). The per cent of time flying was much lower than when feeding the young 4 weeks later. Foraging was heaviest early in the morning, was low through the middle of the day, and then increased slightly in the late afternoon. The per cent of time flying (35.5) compared to the nestling period (65.3) suggests that the adults had to increase their foraging by about 85 per cent to feed three well-grown young. As a considerable portion of that increase must go toward supporting the extra foraging activity, the young must receive only a small fraction of the total food caught. In comparison, a pair of Tropical Kingbirds (*Tyrannus melancholichus*) with two half-grown young were watched at the same time; of 322 feeding sallies, and presumably insects caught, only 63 (19.6 per cent) were fed to the young (Table 6).

DISCUSSION

The data presented here, although limited to two nests, demonstrate temporal and spatial patterns of foraging activities while feeding the young,

TABLE 6

DIURNAL PATTERN OF FEEDING AT A NEST OF TROPICAL KINGBIRD AT BARRO COLORADO ISLAND 30 MARCH–1 APRIL 1968

Time	Date	Number of feeding sallies			Minutes young brooded
		Adult fed	Young fed	Total	
06:20–07:20	31 March	38	10	48	26
08:00–09:00	1 April	27	7	34	7½
09:45–10:45	31 March	36	7	43	22½
11:00–12:00	1 April	52	17	69	5½
13:05–14:05	31 March	55	8	63	0
14:15–15:15	30 March	17	6	23	24
16:00–17:00	31 March	22	6	28	26½
17:05–18:05	30 March	12	2	14	18
Total		259	63	322	130 (27.1%)

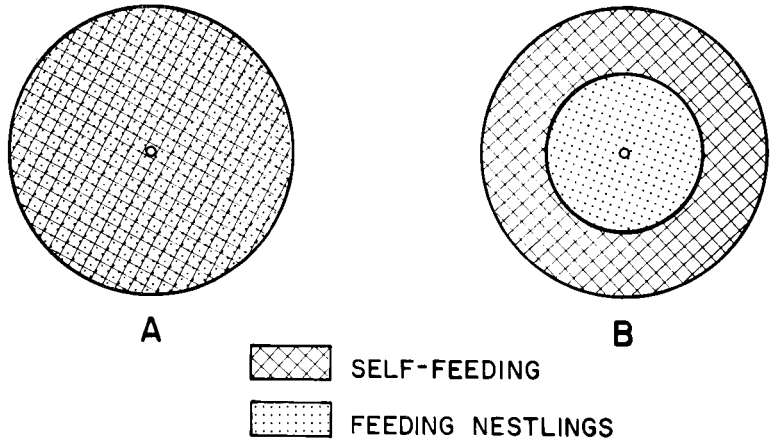

Figure 5. Graphical model of forgaing strategies for territorial birds. In A, all of the territory is used for both nestling and adult feeding. In B, that part of the territory closest to the nest is used exclusively for gathering food for the young, thus reducing the length of trips to the nest. Adults feed themselves from the periphery of the territory.

namely reduction of foraging activity during the middle of the day, and alternation of activity between areas around the nest site and those more distant.

The observed spatial pattern of feeding should optimize the exploitation of food resources within the territory. By temporally separating feeding of the young from self-feeding, the swallows could divide the territory spatially into an area close to the nest requiring only short feeding trips to the nest, and an area distant from the nest where the self-feeding activities of the swallows would not affect the availability of food nearer the nest box.

The advantage to spatial separation of feeding functions lies in reducing the distance necessary for the adults to fly to the nest while feeding the young. Consider a circular territory with the nest exactly in the center. If the adults fed the young from all of the territory equally, the average distance of each flight to the nest box would be ⅔ of the radius (Figure 5). If the young required half of the food gathered by the adults and if the center of the territory was used exclusively for feeding the young, the distance of feeding trips would be reduced by about 30 per cent (½ of the territory lies within 7/10 of the radius). If the young required only ¼ of the food gathered, feeding trips would be reduced in length by ½.

The diurnal foraging patterns of Mangrove Swallows during the dry season suggest that at this time they are limited in their ability to perform

TABLE 7

DIURNAL PATTERN OF FEEDING AT A NEST OF RUSTY-MARGINED FLYCATCHER AT BARRO COLORADO ISLAND 12 MARCH 1968[1]

Forty-five minute periods beginning	06:20	07:05	08:30	09:25	11:20	13:20	14:35	16:00	17:15
Number of feedings per hour	15	23	20	24	36	44	65	24	40

[1] Brood of three young, 14–15 days old, fed by four adults.

work. During the middle of the day the time spent flying in search of food was about 50 per cent, whereas during the early morning and late afternoon they were in the air between 80 and 100 per cent of the time. Presumably the rate of food gathering is proportional to the time spent flying, as well as some function of food abundance, and thus the feeding rate must have been reduced even though the young were poorly nourished. That the adults spent 50 per cent of their time flying indicated that foraging was energetically worthwhile and that suitable food items were available. Other flycatchers that forage at least partly over the water (the Tropical Kingbird and the Rusty-margined Flycatcher, *Myiozetetes cayanensis*) fed their young most frequently during the middle of the day (Tables 6 and 7). Because the swallows fly continuously when foraging and other flycatchers do not, the swallows must metabolize more energy, thus making heat dissipation a greater problem. Furthermore swallows foraging during the middle part of the day are fully exposed to the sun, and their high radiational heat load may possibly prevent them from feeding at high intensity. This is reminiscent of reduced foraging activity and increased shade preference of Cactus Wrens (*Campylorhynchus brunneicapillus*) during the middle of hot days (Ricklefs and Hainsworth, 1968), but in that case heat dissipation is probably limited by the availability of water. If heat load is in fact responsible for foraging patterns of the Mangrove Swallow, the critical limit would be the dissipation of heat by evaporation (respiratory cooling) which is impeded by the high humidity.

Rough calculations of heat loads demonstrate the relative importance of solar radiation. Resting metabolism of a bird the size of the Mangrove Swallow is about 0.25 kcals per hour (King and Farner, 1961). During foraging this might be 4–8 times this value, or 1 to 2 kcals per hour. The total solar radiation incident outside the atmosphere of the earth is about 0.11 kcals per hour per square centimeter (List, 1966). If the absorbtive surface of the Mangrove Swallow were 10 cm^2, its radiational heat load on a clear day could be of the same general magnitude as its metabolic rate, and would have a profound effect on its temperature regulation.

TABLE 8
PERCENTAGE OF TIME BREEDING TREE SWALLOWS SPENT FLYING AT TINNICUM MARSH, PENNSYLVANIA JUNE 1969

	Number of ½-hour periods	Time spent flying		
		Mean (Per cent)	SD	Range
Morning periods (07:00–09:00)				
Sunny	4	77.9	24.0	49–98
Overcast	10	74.8	43.6	35–100
Midday periods (12:00–14:00)				
Sunny	8	63.9	22.8	25–94
Overcast	6	79.1	18.6	52–100

To determine whether the closely related Tree Swallow has similar diurnal patterns of foraging, several active nests in Tinicum Marsh near Philadelphia, Pennsylvania, were watched during June 1969. The age and size of the broods could not be determined because the nests were inaccessible. Also the adults could not be followed individually while foraging because of the large number of swallows in the marsh. However few birds were seen on perches other than their nest boxes, and so it was possible to determine the per cent time spent flying. Half-hour observations were made during morning (07:00–09:00) and midday (12:00–14:00) periods (Table 8). Average time spent flying was depressed slightly during sunny afternoon periods, but during half of the periods, the adults spent more than 80 per cent of the time flying, suggesting that the swallows were able to dissipate heat more readily than their tropical congeners.

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SUMMARY

A pair of Mangrove Swallows was studied during the breeding season of 1968 on the edge of Barro Colorado Island in the Canal Zone. Parental foraging activity during the nestling period showed spatial and temporal patterns. The territory was divided into a feeding ground near the nest from which young were fed primarily, and a more distant area where adults foraged for themselves. Feeding activity was reduced during the middle

of the day, possibly owing to problems of dissipating the radiational heat load.

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