(Anhimidae), for instance, is highly pneumatic and although the reason for this is unknown, it certainly is not the one that holds for the pelican. In the light of this present study, then, the desirability of considering the parts of the respiratory and pneumatic systems in adaptation to different living habits becomes apparent.

Berkeley, California, November 24, 1938.

OBSERVATIONS ON THE NESTING OF THE ALLEN HUMMINGBIRD

WITH FOUR ILLUSTRATIONS

By ROBERT T. ORR

The Allen Hummingbird (*Selasphorus alleni*) is one of our common summer residents in the San Francisco Bay region, usually arriving before the middle of February and remaining in some numbers until the early part of September. From the first day of the arrival of the species to the end of the nesting season its presence is continually forced to human attention through the noise made in flight, by the shrill sound of the courtship dives, and by the constant noisy clashes of belligerent individuals objecting to intrusions upon one another's territories.

Strangely enough, despite the abundance of this diminutive avian representative, we know surprisingly little concerning its nesting activities and the behavior of the young. For this reason the writer kept rather careful notes on an Allen Hummingbird's nest that was situated within three feet of one of the windows of the California Academy of Sciences in Golden Gate Park, San Francisco, during the summer of 1938.

Allen Hummingbirds were first noted this year on February 15. On this day they were numerous in the vicinity of the Academy buildings and many males were seen and heard diving. By the first week in March at least three different females were seen to make regular trips to a box containing some old cotton placed on the roof of the North American Mammal Hall. Sometimes a skirmish would result when two birds arrived at the same time, but this did not often occur. It was not, however, until after the first broods had been raised that the writer's attention was called to a nest which was nearly completed. The structure was almost finished, with the exception of the inside lining, when first discovered on May 6. It was located on the northeast side of an exotic tree, *Eugenia paniculata*, at a height of 5 feet 3 inches above the ground. The nest was on a terminal twig that was drooping at an angle of approximately 45°. Two smaller twigs branched off above the base of the nest and penetrated the lower, central portion, giving it firm support. The outer part of the nest was formed of plant fiber covered largely with lichens and small strips of bark with moss adhering.

On May 6 the female was regularly seen carrying material to line the inside of the nest. This continued for the ensuing few days. On May 10 some cotton was placed on a window sill not far from the nest and this was also used as lining, in addition to plant down. The first egg was laid some time during the morning of May 11. The second egg was deposited the following morning and incubation began immediately. At 1:00 p.m. on May 12, the female was purposely frightened off the nest in order to photograph it. During the 20 minutes following, while preparations were being made to take the picture, she remained in the immediate vicinity, often within 3 or 4 feet of the writer. Three times during this period she was seen to chase away a male of this species. Within half a minute after the window from which the photographs were taken was closed she returned and settled on the nest.

On the second day of incubation considerable time was devoted to observing the behavior of the female. Feeding took place principally in the morning. Between 9:00 a.m. and 12:00 m. she was not seen to be present on the nest more than 6 minutes at a time and the average time present was 2.8 minutes. The average period of absence was 1.4 minutes and the maximum period of absence 3 minutes. This time was mostly devoted to the securing of nectar from the blossoms of *Eugenia* trees growing near-by. Occasionally, however, a portion of the time was spent perched on a summer lilac bush 15 feet away, preening or at rest. Very often when the female appeared about ready to leave the nest to feed, the presence of another member of the same species in the immediate vicinity seemed sufficient to induce her to depart, although, as will be seen later, toward the end of the incubating period no such reaction was apparent. At such times she would fly straight up from the nest for several feet then take after the intruder, calling as she did so. On several occasions she returned with cottony nesting material in her bill. This was inserted into the cup of the nest.

Although the males are generally conceded not to be present in the nesting territory, a male was seen regularly on a perch 40 feet distant from the nest. This individual was frequently seen to chase other Allen Hummingbirds away from this vicinity. On one occasion the female uttered a single abrupt note when feeding near the male who was on his perch calling.

While continuous observations were not carried on during the afternoon, the nest was examined at least four times an hour between 1:00 and 5:00 p.m. and frequently for 10 or 15 minute periods. At no time was the female seen voluntarily to leave to feed, although once she was disturbed intentionally for photographic purposes for about half an hour. When sunlight, reflected from a mirror, was first focused on her she flew up in alarm; but after this was repeated several times she became accustomed to the bright light and remained settled on the nest.

On the third day of incubation no differences in behavior were apparent. Observations, made during most of the morning between 9:00 a.m. and 12:00 m., showed the female to devote much of this time to feeding. She remained on the nest no longer than 8 minutes at a stretch, averaging 4.1 minutes, and she was absent no longer than 2.5 minutes at any one time, the periods of absence averaging 1.1 minutes. On three different occasions, when the female left the nest, a male was seen to alight on the same perch as was occupied by a male on the previous day. Each time he left almost simultaneously with the return of the female to the nest. Twice this male was seen to make low dives within 20 feet of the incubating female. Once the female was seen to leave the nest and fly at the perching male and scare him away. Another time the female was seen to fly from the nest, right past the perched male. The latter immediately followed her, both birds calling as they flew, but he very shortly lit on another perch while the female disappeared from the observer's view.

The manner in which the female left and returned to the nest was rather constant. On leaving, she would usually rise straight up for several feet, then fly away, calling when she was 10 to 15 feet distant. The call normally given near the nest was a low "chut." On returning she would frequently utter the same note within a foot or so of the nest and not uncommonly after or while settling on the eggs. The nest was almost invariably entered from the same side. The edge of the nest was never perched upon, as the female literally flew onto the eggs. Immediately on alighting, judging from the vibrations of her body, she moved her feet rapidly and made from a quarter to a three-quarter turn. This also moved the eggs. When finally settled she moved her head about frequently, taking note of her surroundings. The presence of a person, however, in the immediate vicinity would cause her to remain perfectly motionless.

Few evident changes in behavior were apparent during subsequent days of incubation, except for a decrease in the number of trips made daily for food. This was correlated with a slight increase in the periods of absence from and presence on the nest. On May 21 the average time spent on the nest in the morning was 7 minutes and the longest time present was 9.5 minutes. The longest period of absence was 3 minutes and the average period of absence 1.6 minutes. At this time the female was rarely induced to leave the nest because of the proximity of other hummingbirds. Once a male hovering close overhead caused her to leave in pursuit. Another time, however, a male hovered over her and then fed from blossoms no more than 2 feet distant without inducing her even to move. Other females in the vicinity, either feeding or flying by, aroused no reaction, nor did a pair that copulated in mid-air within 18 feet of her.

On the evening of May 26 the eggs were as yet unhatched; but when examined at 8:20 the following morning one of the young had emerged. At 9:10 a.m. the female upon returning, after feeding on the nectar of *Eugenia* blossoms in the nest tree, was seen for the first time to perch on the rim of the nest. She then probed her bill into the lower part of the cup, but from the observer's position it was impossible to see if she was feeding the newly hatched young, moving the remaining egg, or merely adjusting the lining of the nest.

At 2:30 p.m. the second young was seen emerging from the remaining egg. At 3:07 p.m. the female was flushed and the nest and contents examined. The down of the first hatched young was completely dry and fluffed out, being present in small quantities

Fig. 10. Female Allen Hummingbird brooding young 5 days old; June 1, 1938.

along parts of the spinal tract. The second young was still struggling to free itself of half the shell. The skin of both young was very darkly pigmented. Their eyes were closed and their bills were short, fleshy-yellow in color and did not differ noticeably in shape from those of certain small passerine birds. The inside of the mouth was a brilliant orange-yellow. During the afternoon the female was seen to remain away for as long as 5 minutes. On returning once she was seen to perch on the rim and extend her bill down into the nest, but from the observer's position it was not possible to determine whether or not she was feeding the young.

According to these observations the period of incubation in this case was a full 15 days. This is a considerably longer incubation period than Dawson (Birds Calif., vol. 2, 1923, p. 928) gives for the Allen Hummingbird. That author states: "Eggs are deposited on alternate days; and incubation, counting from the deposition of the second egg, lasts twelve." It is, however, slightly less than found by Clabaugh (Condor, vol. 38, 1936, p. 176). Mention might also be made of the fact that eggs in this instance were deposited on consecutive rather than alternate days as is the usual custom.

During the first few days the female spent nearly as much time on the nest brooding as she had done previously incubating. By the end of the week, however, there was a noticeable decrease in the brooding as well as a great increase in the amount of time devoted to securing food. By June 8, when the young were 12 days old, brooding had practically ceased. Sometimes, after feeding the young, she would hop onto the nest, but never for more than half a minute. When the young were nearly ready to leave, due to their size it became physically impossible for the female to brood even though she would occasionally make an attempt to do so.

The female, upon returning to feed the young, would usually give several low call notes as she approached the nest. Invariably she perched on the same part of the rim. As a general rule about 5 seconds elapsed before feeding commenced. During this time the young, if hungry, would raise their heads and silently open their mouths. Following this the female would rather rapidly insert her bill into the open mouth of one of the young until the tip of the culmen of the latter almost reached the base of the parent's culmen. Food was then transferred to the young during which time the throat of the female was seen to vibrate rapidly and the young occasionally jerked and yanked at the bill of the adult. Five feedings were usually made each time, although sometimes the number was less, these being given alternately to the two young without favoritism. The first feeding was generally the shortest. The amount of time required for each feeding varied from 5 to 20 seconds, averaging about 10 seconds.

Food was secured by the female principally from the blossoms of *Eugenia*. Small insects were occasionally seen to be captured from the air and probably were taken to a greater extent from cobwebs.

The young maintained a sanitary condition in the nest. Defecation was accomplished by raising the posterior portion of the body to the rim of the nest and forcibly extruding excrement 6 or more inches into the air, clearing the nest, thus in the same manner as this act is accomplished by young raptorial birds.

One of the young was about 2 days in advance of the other, regarding development, up to the time the nest was left. When 6 days old the young were seen to be very darkly pigmented, more so than when hatched. Juvenal feathers had not yet appeared, nor were their eyes open. At this time the female was seen to remain away from the nest for as long as 20 minutes at a stretch. On the 7th day a few feathers were in evidence along the spinal tract, and the primaries and secondaries were seen beneath the surface of the skin on the larger of the young. By late afternoon on the 8th day the rectrices were seen

beneath the surface of the skin, and the remiges were protruding through the skin on this individual. More feathers were likewise seen along the spinal tract as well as the capital, humeral, crural and ventral tracts. No juvenal feathers were in evidence as yet on this date on the smaller of the two young, with the exception of the rectrices and remiges.

On the 9th day the bill of the larger bird was dark along the culmen from base to tip as well as along the sides just above the cutting edge. The area between, however, was dull yellow. The bill of the smaller bird was mostly dull yellow with a small amount of dusky color present along the culmen. The inside of the mouth of both individuals was still a brilliant yellow. The primaries and secondaries of both birds protruded through the skin, but were not as yet through their sheaths. Feathers were apparent on the dorsal body and head tracts of the smaller individual. All of the feather tracts of the larger bird were in evidence on this date and most of those of the spinal tract were one millimeter through their sheaths.

By the 11th day practically all the feathers of the dorsal body tracts of both young were out of their sheaths. Those of the larger individual extended as much as 2.5 milli-

Fig. 11. Young Allen Hummingbirds 12 days old being fed. On this day the eyes of the largest young were seen open for the first time; June 8, 1938.

meters beyond the broken ends of their sheaths. The feathers of the ventral body tracts, the crural tracts and the feather tracts of the head had not yet emerged from their sheaths. The bills of both birds were considerably darker. The smaller of the two had, in most respects, on this date advanced no farther in development than the larger bird

on the 9th day. The parent on this date was noted to remain away from the nest for as long as 27.5 minutes.

On the 12th day the eyes of the larger bird were at times partly opened. The upper mandible was yellowish only at the angle, being dark otherwise. The lower mandible was dark beneath but yellowish along the sides almost to the tip. The culmen measured 4.9 millimeters. The rectrices were just breaking through their sheaths on this date although the primaries and secondaries were already well through. The feathers of the capital tracts were not as yet through their sheaths although those of the crural and ventral tracts were. Growth appeared to take place very rapidly from this time on.

By the 13th day all the feathers, excepting those of the forehead, were through their sheaths on the larger bird. The remiges extended about 2 millimeters beyond the broken ends of their sheaths. The culmen measured 5.8 millimeters. This individual was seen to turn around in the nest a number of times, observe its surroundings and do considerable preening. The smaller bird's eyes were very slightly opened on this day. Its bill was much darker than on the previous day. The remiges were, likewise, just beginning to break their sheaths. On this day the female was noted once to stay away for a 40 minute period.

On the 15th day the young were seen to be much more alert than previously noted. The larger individual kept its eyes open most of the time and when a finger was poked

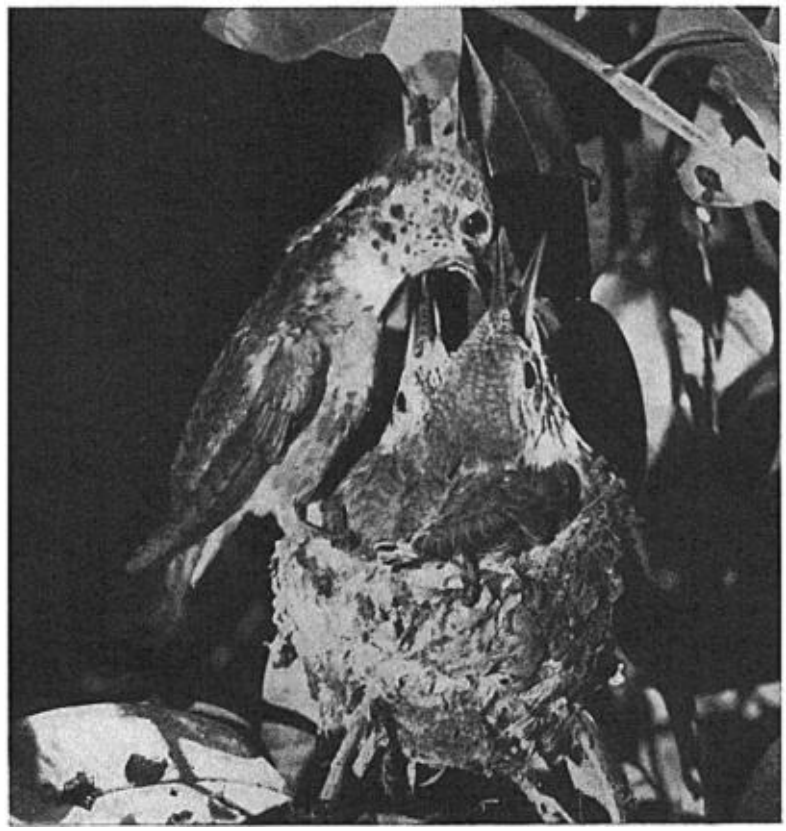

Fig. 12. Young Allen Hummingbirds 19 days old being fed; June 15, 1938.

near, it would call, giving frequent utterance to a relatively low note until the offending object was withdrawn. A great deal of time was devoted to preening, also to shaking and fluttering the wings. The smaller bird was much more quiet and kept its eyes closed most of the time. The only feathers not yet out of their sheaths on either bird were those on the anterior part of the head just above the base of the culmen.

The 16th day showed both birds to be more active. Only 12 feathers on the forehead of the larger bird were as yet sheathed. The primaries were 7.5 millimeters long from tip of sheath to tip of feather. The upper mandible of both birds was now entirely dark, but the proximal portion of the lower mandible was still partly yellowish.

On the 18th day the female was seen to remain away from the young for as long as 45 minutes. The contour feathers of both young now completely covered their bodies and only a few wisps of natal down still adhered to the feathers of the posterior part of the spinal tract. The culmen of the larger bird measured 9.1 millimeters, its longest primaries 9.7. During the afternoon it became quite warm and the young were seen to keep their mouths open quite a bit. They were keenly observant of their surroundings, noting insects flying in the immediate vicinity of the nest as well as persons passing along a nearby road. The wings were stretched frequently.

The larger of the two young was seen to fan its wings for the first time on the 19th

Fig. 13. Young Allen Hummingbirds at 21 days of age. The larger bird, perched on the rim of the nest, left the following day; June 17, 1938.

day, and on the 20th day it was seen to perch at times on the rim of the nest. On the 21st day this individual spent much time on the rim of the nest and fanned its wings frequently. Occasionally it would stretch its neck and extend its tongue out to touch surrounding leaves.

On the morning of the 22nd day the larger bird was seen to spend most of the time perched on the rim of the nest. No remnants of down were now apparent even on the rump. The bird was present at 1:15 p.m., but when the nest was next examined at 4:00 p.m. only the smaller of the two young remained. The young that had left was not to be seen in the vicinity.

On the 24th day the remaining young hummingbird was seen to behave in a manner similar to the larger individual the day before it left the nest. Much time was spent perched on the rim of the nest and the wings were fanned frequently. The parent was seen getting food and feeding this young often, and from her behavior it appeared improbable that she was still feeding the individual that had left two days previously.

At 9:35 a.m. on the 25th day the remaining young hummingbird was observed sitting in the cup of the nest. At 9:40 a.m., when next seen, it was perched on a branch three feet distant from the nest. The female was noted poised a few feet away. The young was then observed to vibrate its wings several times, once lifting its body up and merely holding on to the branch with one foot. During the ensuing 15 minutes the female was seen to feed the young twice. At 10:05 a.m. the writer reached out with a pole to see what would occur if the bird were prodded. When the pole came within an inch of the young it rose in the air, giving the same low call as the female used in approaching the nest, flew through an opening in the foliage of the tree, then flew down over a roadway and disappeared from sight in a clump of trees. Although careful observations were made in this area during the afternoon, the young was not definitely seen again.

In summary, observations were made upon a single Allen Hummingbird nest over a period of 47 days. The incubation period in this instance was found to be 15 days. The female obtained food principally during the morning hours. A male, thought to be the mate of the nesting female, was frequently seen in the vicinity of the nest tree during incubation and was tolerated to some extent by the female. Brooding was carried on by the female during the first week, then tapered off rather abruptly, practically ceasing by the 12th day. The decrease in time spent in brooding was correlated with an increase in time devoted to obtaining food. Juvenal feathers first appeared on the dorsal body tracts of the larger of the two young on the 7th day. The eyes of the young did not open until the 12th and 13th days. Growth appeared to take place more rapidly from the 12th day on. The young left the nest on the 22nd and 25th days, respectively, after hatching.

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