

LIFE HISTORY OF THE CACTUS WREN
Part I: WINTER AND PRE-NESTING BEHAVIOR

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This life history study of the Cactus Wren (*Campylorhynchus brunneicapillus*) began as an endeavor to determine the actual behavior of a small population of wrens in the vicinity of our home near Rillito Creek, at the northeast edge of Tucson, Arizona. A few supplementary observations were to be made in other places for the purpose of checking our local findings, but travel restrictions of World War II interfered somewhat. After the war, however, permission was obtained from the United States Forest Service to work on the Santa Rita Experimental Range, 30 miles south of Tucson. This made possible the study of population problems in a larger area. In addition to the field work, all the important published references in the ornithological literature were examined to obtain the views and data of other workers on this species.

Our field notes, based entirely on observations of living birds, cover a period of about twenty years. No specimens were collected; we tried to disturb the birds as little as possible. Progress was slow at first because of the difficulty of working with a species in which the sexes are identical in appearance. Later, from 1939 to 1949, when color banding of adults and nestlings was consistently practiced, information of more reliability was obtained. Since the investigation was conducted entirely in our spare time, on mornings, evenings, and week-ends, there were many delaying interruptions and digressions. There are as a consequence many incomplete records. Nevertheless, we feel we have gathered enough data to reveal a fairly clear picture of the behavior patterns of the Cactus Wren. It should be emphasized that our local population, living in a suburban environment and constantly harassed and disturbed by human activities, may not have been truly representative. Life in more open, natural, desert surroundings may be somewhat different. In some respects it is perhaps harder; predators are more numerous, and food supply may fluctuate to a greater extent than in the vicinity of human establishments. In the main essentials, however, we found that the pattern of activity was the same on the desert range as that in our back lot.

To Walter P. Taylor should go the credit for suggesting this fascinating problem. We wish to express our thanks to W. H. Behle, Herbert Friedmann, L. M. Huey, Seth Low, M. M. Nice, and A. L. Rand for aid in searching out bibliographic references, distribution records, and nesting areas; to Alden H. Miller and Frank A. Pitelka for advice on preparation of manuscript; to J. T. Marshall, Jr., and A. R. Phillips for nesting data; to J. J. Thornber, L. Benson, and C. T. Mason, Jr., of the University of Arizona Department of Botany for many courtesies in identifying plant specimens; and to J. E. MacDonald of the Institute of Atmospheric Physics at the University of Arizona for help in securing climatological reports. We are deeply grateful to Raymond Price, who, as director of the Southwestern Forest and Range Experiment Station in 1953, granted us permission to work on the Santa Rita Experimental Range; we are also indebted to H. G. Reynolds and S. C. Martin, who extended this courtesy in succeeding years and made accessible to us their valuable data on the range.

METHODS

No particular difficulty was experienced in trapping the wrens in accessible roosting nests after dark. A home-made trap of one-quarter inch mesh hardware cloth, 6×6×12 inches, closed at one end, had a swinging door at the other end so arranged that it could be closed the moment the wren entered. As soon as the trap was thrust over the nest entrance, the startled wren usually scrambled into it at once. This easy method, however,

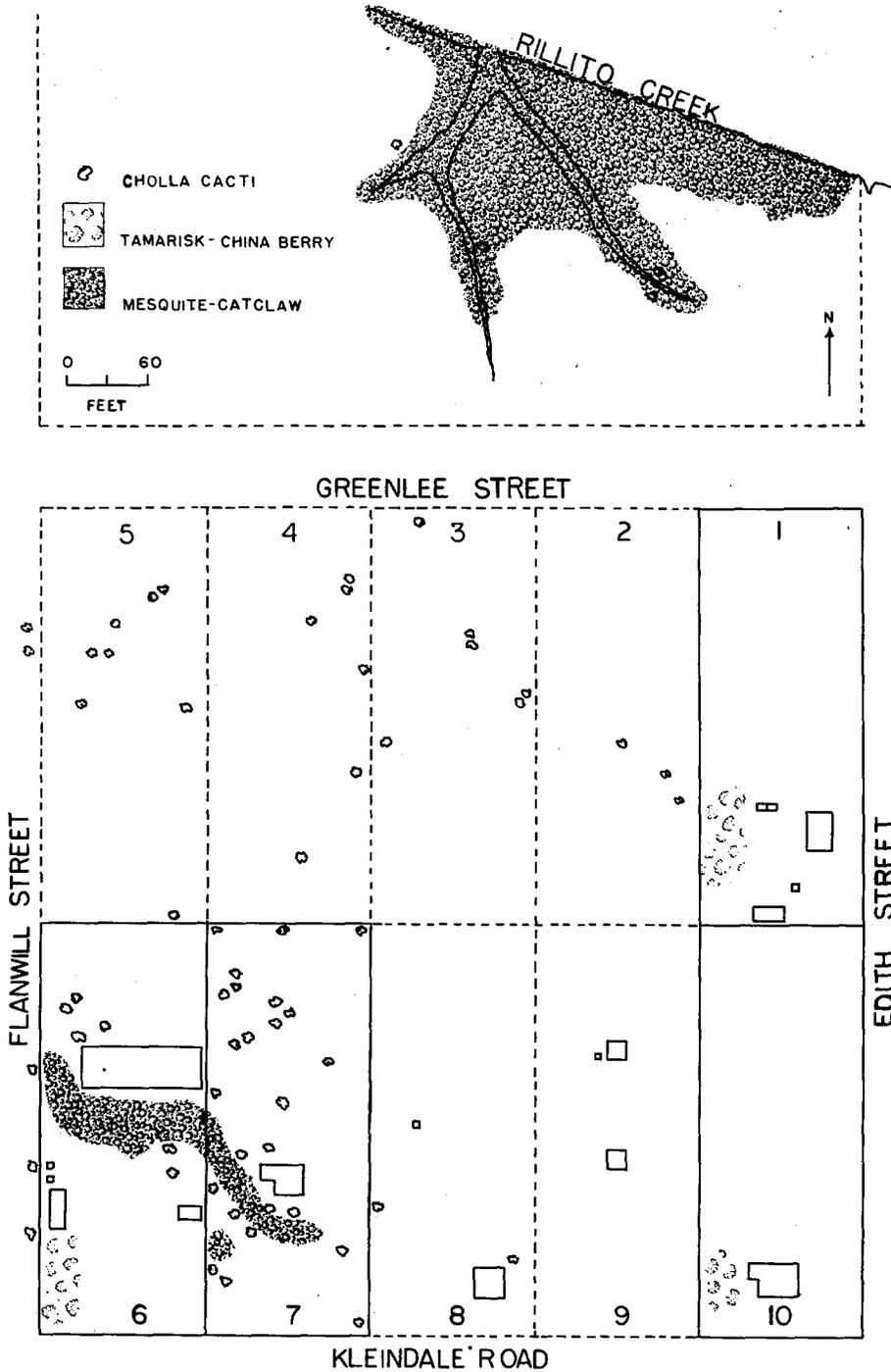


Fig. 1. Kleindale Road study area in 1941. Solid lines indicate fences; dashed lines, lot boundaries. Creosote bush association covered all unshaded areas except streets.

had the disadvantage of causing desertions of roosting nests. The birds could not be successfully returned to their nests in darkness; they had to be kept indoors over night. In order to avoid this association of danger with the wren's roosting nest, a small false-bottom or treadle type of trap was substituted. It was placed on the ground and baited with bits of bread or cotton. Competition for the food by English Sparrows (*Passer domesticus*), White-crowned Sparrows (*Zonotrichia leucophrys*), Curve-billed Thrashers (*Toxostoma curvirostre*), and even Gila Woodpeckers (*Centurus uropygialis*) caused numerous delays, so that the wrens were seldom captured at the desired time.

All trapped wrens were banded with numbered aluminum bands supplied by the United States Bureau of Biological Survey (later the Fish and Wildlife Service). In addition each wren received one or two colored celluloid bands to facilitate identification in the field. It was found that these color bands could easily be recognized from a distance of at least 100 feet with 8× binoculars. For use in daily records each wren was arbitrarily assigned the letter H, followed by a number indicating its order in the banding log. When the sex became known, males were in addition given the letter M, females the letter F, thus HM-1, HF-2. Cholla cacti were numbered, and as nests were built in them, each nest received the cholla number and a letter designating its order of construction, thus 6A, 14C.

From 1939 to 1957, a total of 71 Cactus Wrens was banded in the Kleindale Road area. Of these, 34 were adults or full-size immature birds; the remaining 37 were nestlings.

HABITAT

The area selected for study comprised a block of ten acres, on one of which, lot 7, our home was located. This block is bounded by the following streets: Kleindale on the south, Edith on the east, Greenlee on the north, and Flanwill on the west. Its northern boundary lies about 400 feet from the south bank of Rillito Creek (figs. 1, 2, 3). The elevation of the area is about 2400 feet above sea level, and the land slopes gently northward down to the creek. In 1939 five of the acre tracts on Kleindale Road and one on Greenlee contained small residences with various auxiliary buildings such as chicken houses and garages. The remaining four acres were unoccupied. Creosote bush (*Larrea tridentata*), the widespread indicator of the Lower Sonoran Life-zone, predominated not only in the study area, but it was found for considerable distances east, south, and west. Its density varied greatly. Our lot, which had been purposely left in its original condition as much as possible, contained at least 350 shrubs of this species, ranging in height from one to six feet. Across a corner of the tract, running from southeast to northwest, an old, abandoned, shallow irrigation ditch was bordered by an irregular growth of low mesquite (*Prosopis juliflora*) and catclaw (*Acacia greggii*). A denser fringe of the same plants marked the south edge of Rillito Creek. A few cultivated trees, tamarisk (*Tamarix aphylla*) and China berry (*Melia azedarach*), had attained an adult height along the front of the residences on Kleindale Road. Here and there cholla cacti emerged in the almost uniform expanse of creosote bush. Our lot also supported the maximum number of these—about twenty plants of sufficient size to provide shelter and nesting sites for Cactus Wrens. Cane cholla (*Opuntia spinosior*) was the common species, with a few jumping cholla (*O. fulgida*) and staghorn cholla (*O. versicolor*) interspersed. Other shrubs, desert broom (*Baccharis sarothroides*), desert thorn (*Lycium berlandieri*), and Mormon tea (*Ephedra trifurca*), were few in number and of little significance in relation to shelter or nesting facilities for birds.

For the most part the soil was bare, brown, and sandy. If winter rains were abundant, numerous small annual plants appeared in early spring, rapidly carpeting the ground

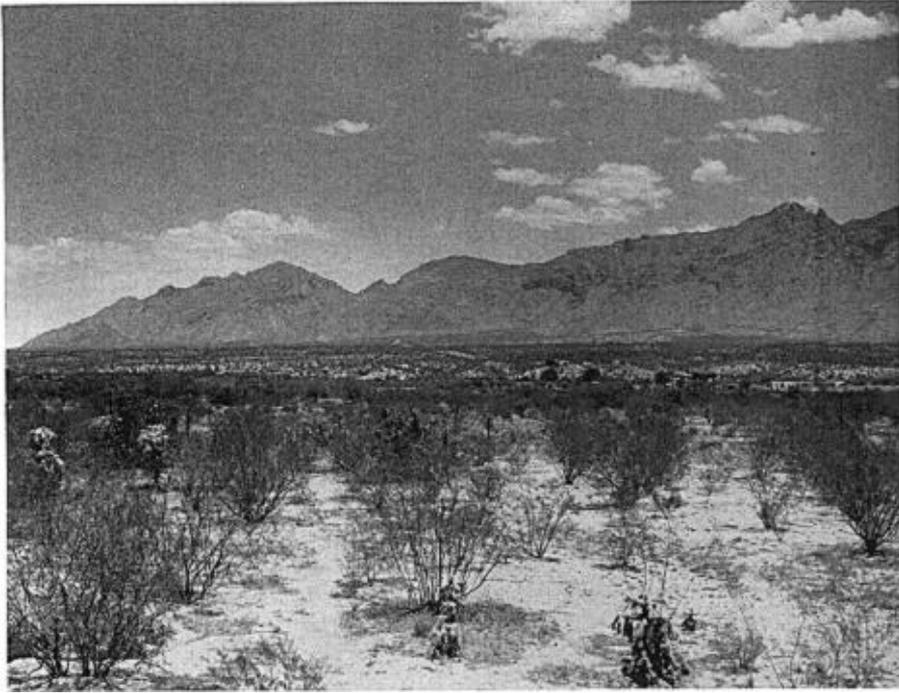


Fig. 2. Kleindale Road study area, looking north from lot 7 in 1938.

with flowers. The most conspicuous were the bladder pod (*Lesquerella gordonii*) and filaree (*Erodium cicutarium*). The other common spring annuals were: the grasses, *Festuca octoflora*, *Schismus barbatus*; the mustards, *Lepidium lasiocarpum*, *Sisymbrium irio*, *Descurainia pinnata*, *D. sophia*; *Astragalus nuttallianus*, *Erodium texanum*, *Bowlesia incana*, *Phacelia crenulata*, *Pectocarya platycarpa*, *P. recurvata*, *Lappula redowskii*, *Cryptantha angustifolia*, *C. barbiger*, *Amsinkia intermedia*; the plantains, *Plantago insularis* and *P. purshii*; *Stylocline micropoides*, and *Evax multicaulis*. All these annuals completed their cycles of flower and fruit by the middle of May, then they dried up with the increase in daily temperatures. After the summer rains, which usually begin in July, these plants were replaced by a different group, less numerous in species. The most abundant were: the sixweeks grama (*Bouteloua barbata*) and needle grama (*B. aristidoides*); *Eriogonum deflexum*, *E. tricopes*, *Boerhaavia caribaea*, *B. spicata*, *B. wrightii*, *Tribulus terrestris*, *Kallstroemia grandiflora*, and *K. parviflora*.

Ordinarily no water was available on the ten acres other than that from dripping faucets or bird bath pools constructed by interested residents. Rillito Creek was normally a dry bed of sand. Only after summer cloudbursts in the nearby mountains, or after unusually heavy winter rainfall, did it carry any water, and then there was water only for a relatively few days. The brief, sometimes torrential summer rains often carried away portions of the top soil in the vicinity, for the plant cover was seldom heavy enough to prevent erosion.

The fast-growing community of Tucson produced many changes in the Kleindale Road area in the course of the 20-year period of study. While we tried to leave as much as possible of the original vegetation on our lot, we had no control over the lots of our neighbors. A sand and gravel company took over the south bank of Rillito Creek, re-

moved all of the vegetation, and sold the top soil. The creosote bushes south of Kleindale Road were bulldozed away to make room for 25 small houses. Most of the chollas on the tract, with the exception of those on our lot, gradually disappeared as houses were built and the residents found the spiny twigs objectionable to children and pets.



Fig. 3. Kleindale Road study area, looking south through lot 7 in 1956.

Lots 2, 3, 4, and 5 along Greenlee Street were swept clean when a riding stable moved in with its horses. Ornamental plants increased. Numerous electric and telephone poles framed the area. The grading of new streets changed and diverted the natural drainage channels.

STATUS

Cactus Wrens appear to be strictly resident. They can be seen in southern Arizona in suitable localities every month of the year. The adult wrens, which we banded, remained with us throughout the winter with extremely slight shifts in territory. We never observed any increase in the wren population during the early spring months, as would have occurred had there been an influx of migrants from the south. The population peak, which was attained in late summer, was produced entirely by the addition of immature birds; these were raised in the vicinity, intermingled with the adults, and tentatively probed into adjacent territories. The population gradually decreased as the immature birds vanished, reaching its lowest point at the end of the winter. Adult wrens which suddenly disappeared were usually almost immediately replaced by new birds. Evidently unmated individuals, in nearby but less desirable territories, gradually moved, whenever possible, into more favorable locations.

WINTER TERRITORY

At Tucson the period of what might be termed routine winter activity was very brief. November could be called the dormant, stabilized month. Each year's cycle actually began in December. The basic "population" of one pair of Cactus Wrens occupied approximately the same area which it had used in the course of the spring and summer months for breeding purposes. In addition, this pair usually tolerated, in loose attach-

ment, some immature birds of the preceding nesting period, chiefly the surviving members of the pair's own offspring that were now in adult plumage, and an occasional outsider. Often the group foraged as a unit without apparent antagonism between any of its members. At times, some of the wrens might venture north to the bank of the Rillito, or they might trespass into land occupied by other wrens. Although flocking behavior has been reported, our local population was never augmented by the addition of wrens from neighboring territories in search of food.

Howell (1916:213-214) saw flocks of from 6 to 30 or more Cactus Wrens going through the tops of the cottonwoods along the Rillito in the cold weather. It is not surprising that they would visit the cottonwoods, for these trees are adjacent to the cactus-covered bajadas on the north bank of the Rillito and would present only a small extension of territory. It is the number of wrens that is exceptional. We have never observed Cactus Wrens in such large numbers anywhere in Arizona, nor have we been able to find any other reference to such extreme flocking behavior in the literature. Conceivably, the combination of a successful breeding season with the survival of most of the young birds of three or four broods could produce such an extraordinarily large family group. Otherwise it would require the supposition that the occupants of at least half a dozen adjacent territories combine with their offspring into a compact group for the purpose of foraging. The abandonment, even temporarily, of a definite territory—and the Cactus Wrens in our area were strictly territorial in their habits—for communal feeding seems illogical. Howell did not report the extent of the cottonwood foraging expedition. It seems probable that it was a case of a sudden, abundant, concentrated food supply in the center of a considerable population of wrens. The birds of the surrounding area, within sight of each other, would be attracted to this center radially as though by centripetal force, and they would disperse to their respective sectors in the circle as soon as satisfied. An observation by Dr. R. B. Streets of the University of Arizona (personal communication) would seem to support this view. On January 4, 1953, he saw large numbers of Cactus Wrens in the tops of the date palms in a small grove at a ranch near Tanque Verde Creek east of Tucson. On later visits by us, no wrens were seen in the palms, but we found them in the nearby desert in their usual habitat.

The Kleindale Road territory must have included at least fifteen acres during the winter months. It is doubtful if all of this area was visited regularly each day. Frequently the group of birds stayed in the vicinity of the houses where food was more plentiful.

ROOSTING NESTS

Our Cactus Wrens required a covered roosting nest in all months of the year. In the Tucson area each adult wren occupied nightly its own nest. At no time did we find more than one wren in a winter roosting nest. Any available nest was used as long as it was habitable. Usually by the end of the breeding season some of the old nests had deteriorated; others had been relinquished to the immature birds. The adults selected new sites and built again. Ordinarily, under more normal, or perhaps ideal, conditions, these roosting nests would probably have been used throughout the winter. Here, however, because of frequent nest destruction by the Curve-billed Thrasher the Cactus Wrens were engaged in building during the entire winter.

The location of the roosting nests naturally depended upon the availability of cholla cacti. These cacti were most numerous in the western portion of the ten acres. The usual winter territorial area here was about ten acres, with irregular additions of five adjacent acres. The center of activity, however, lay not in the center of the tract but far to the edge. As shown in figure 4, which indicates the locations of the roosting nests during the

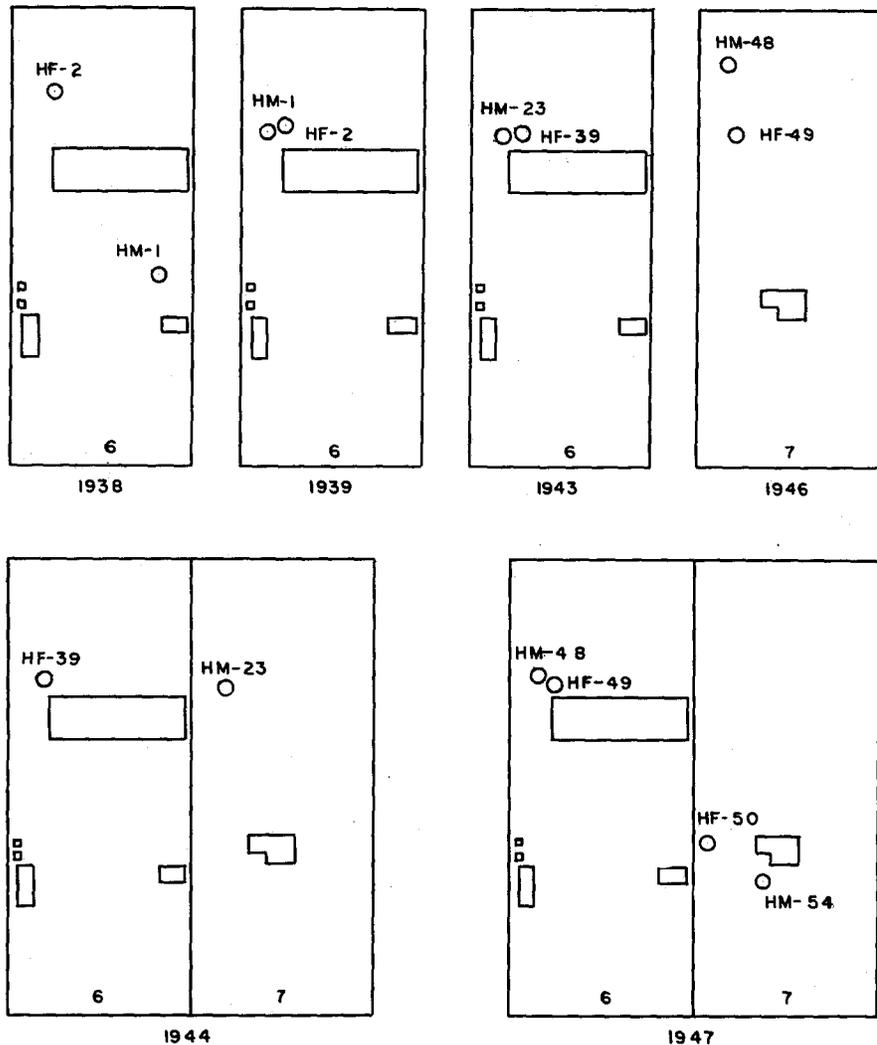


Fig. 4. Locations of roosting nests of a pair of Cactus Wrens in lots 6 and 7 in November and December of 1938, 1939, 1943, 1944, 1946, and 1947. Circle with wren's number indicates nest.

months of November and December for the years 1938, 1939, 1943, 1944, 1946, and 1947, lots 6 and 7 were preferred by the resident pair.

The roosting nests of the male and female were seldom far apart. In three of the years they were in the same cholla. The maximum separation of 140 feet occurred in 1938. Distances to other members of the winter group varied considerably. Some were as close as 100 feet, others much farther. A few nests were never located, suggesting the probability that some of the wrens had strayed in from the area to the east. The daily variation in the local winter population of from three to eight birds would tend to confirm this. There were not enough roosting nests in the territory to house the entire population.

Cholla cacti were used almost exclusively for nest sites. Only when the wrens were hard pressed by competition, did they use other places. These exceptions were catclaw bushes, an ornamental *Pyracantha*, an English Sparrow roost under the eaves of a garage, and an English Sparrow nest box in the back lot, of which the owners were dispossessed. Nest heights, of course, were limited by the height of the chollas, the maximum being eight feet. Because of its open growth, cane cholla seldom offered a site lower than three feet. Jumping chollas had lower, denser crowns. Yet, no nests were placed

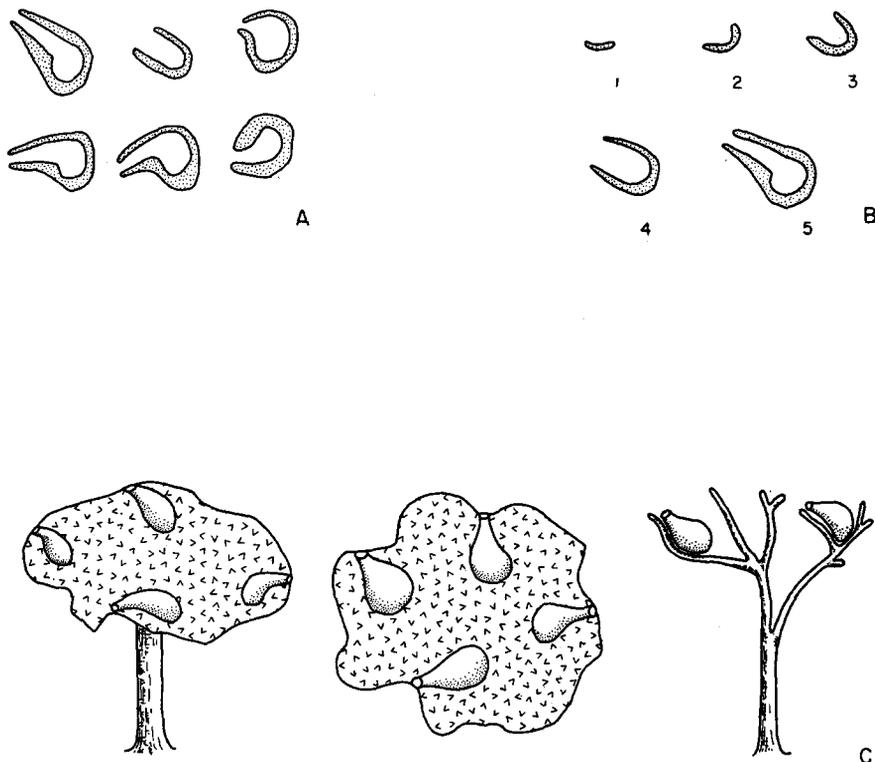


Fig. 5. A. Common variations in the shape of Cactus Wrens' nests. B. Stages in the construction of a roosting nest. Occupation usually begins at stage 3. C. Common locations of roosting nests in cholla cacti; left, *Opuntia fulgida*; center, *O. fulgida*, top view; right, *O. spinosior*. Nest entrance usually faces outward. The number of nests in a cholla varies, there being seldom more than two usable nests.

below three feet. The average height, determined partly by the configuration of the cholla crown, and partly by the choice of the wren, was from four to five feet.

There is no essential difference between the roosting nest and the breeding nest. In fact, they are sometimes interchangeable. The Cactus Wren's nest is probably the best known part of this interesting bird's history (Bailey, 1922:163-168; Woods *in* Bent, 1948:220-223; Brandt, 1951:679-680), for the nests are too conspicuous to overlook or neglect. Many variations in structure have been observed, but none was noted that altered the basic design of a pouch-shaped affair with an entrance at one end. The "standard" or "normal" nest is one about twelve inches long, sloping downward from the entrance at a 30° angle. It has an entrance, whose diameter is roughly one and a half

inches, and a well-defined, cylindrical vestibule of the same diameter, of varying length, leading to a nest cavity, into which it drops abruptly. The cavity may be three inches in diameter. In profile the exterior is pouch-shaped; the interior has the form of a retort.

Variations in the position and shape of the nest are undoubtedly sometimes caused by the wren's inability to choose the proper site (fig. 5). Such inability is not necessarily due to inexperience, for adults may have the same difficulties in choosing a nest site as immature birds. Nest sites are never exactly alike. The floor of the nest cavity requires a support of twigs. If the place selected is of insufficient length, the vestibule will be shortened or even absent. The nest may be little more than a wide-mouthed tumbler set on edge. Occasionally this problem is solved by pushing more and more material into the cavity, forcing the cavity backward and downward until it becomes suspended from the vestibule without under support. This situation can lead to changes in the slope of the vestibule. A longer floor results in a longer vestibule; sometimes this vestibule is 12 to 15 inches long before it ends in a flaring cone of grass stems. A "doorstep" of some sort is always necessary, for the entrance is too small to admit a flying bird, and the funnel of grasses is too weak to support a wren's weight. This "doorstep" is usually a twig or a branch growing below or at the side of the entrance.

The general form of the nest is apparently a reflection of inherited behavior, but the materials used in construction depend upon what is available in the vicinity of the particular site. On the Santa Rita Experimental Range and in other parts of the better-watered, eastern Arizona desert, the nests were constructed of dried grasses, with a weak skeleton framework of coarser grasses and such intricately branched species as the Boerhaavias. Farther westward, in the Organ Pipe Cactus National Monument in southwestern Arizona, where grasses are often less abundant, we found *Eriogonum deflexum* used almost exclusively for the exterior walls of the nests. The dark, reddish-brown color of these nests was in striking contrast to the pale straw hue of the eastern nests. Along the arid, western slope of the Beaver Dam Mountains in southwestern Utah, the Joshua tree (*Yucca brevifolia*) provides a supply of dry, shredded fibers for nest material. The few grasses which can be obtained are used in the interior lining. When possible, the nest cavity is carpeted with feathers. Plant down is seldom used.

When civilization creeps into the wren's domain, an abrupt change takes place in the nest materials used. Almost anything imaginable is gathered up and fashioned into a nest. Bits of newspaper, tissue, cotton, string, rope, rags, fur, lint, and, above all, chicken feathers replace the native materials.

It has been difficult to observe the act of selecting a nest site. In most cases preliminary activity was not noticed, for our attention was first attracted only after construction was begun. Indecision or uncertainty in choice must occur, however, because it is not unusual to discover small bits of nest material that have been placed in various chollas and then abandoned. An extreme example is that of H-35, a wren which had lost two roosting nests in the fall of 1941, the last on December 6. On December 7, at 9:50 a.m., this wren was observed inspecting two damaged nests in cholla 23. It pulled a straw from nest 23A and carried it around to nest 23B in the same cholla. Evidently this latter nest was not satisfactory, for it now began gathering material on the ground and placing it in cholla 3. Soon it was back to nest 23B trying to straighten out the disarray of grasses and then adding more material. Again it left. This time it did not return to work until 11:30 a.m. Still not satisfied, it moved to cholla 22 and started another foundation. This work was interrupted when a Curve-billed Thrasher climbed the cholla and took up a position on the floor of the nest. H-35 eyed the thrasher a moment, then it flew to cholla 3, where it apparently looked for another site. Undecided again, it flew to cholla 14 and inspected an old nest remnant. Then it flew up to the eaves of the nearby garage.

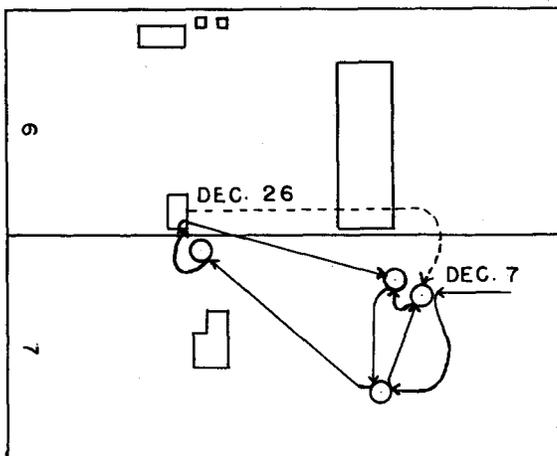


Fig. 6. Movements of Cactus Wren in search of roosting nest site on December 7, 1941. Final choice made on December 26.

Here it entered, disturbing the English Sparrows who possessed this roost. A few minutes later H-35 carried some feathers to cholla 22. Nothing further was done on these tentative starts until December 26, when work on nest 23B was resumed. This nest was completed and occupied. Until it made the final decision, it is believed the wren roosted under the garage eaves. All of the chollas mentioned were in the center third of our lot. They formed an isosceles triangle 60×120×120 feet. Here, apparently, was a firm choice of area, but there was considerable uncertainty in regard to the particular site (fig. 6).

The actual start of a roosting nest may take place at any time of the day. For example, on October 4, 1941, a wren began to lay the foundation of nest 1D at 3:00 p.m. Sometimes an unpleasant disturbance at a roosting nest after dark, such as being trapped, may cause the wren to seek a new site the next day. Once the nest has been started, however, construction usually begins early each morning, sometimes before sunrise. The first two or three hours are the busiest. Then work slows down, seldom continuing until noon. There is occasionally another period of activity, usually a brief one, in late afternoon. It would be logical to suppose that the rate of construction would vary with the urgency; perhaps it also varies with the individual. There is some evidence in our incomplete records that suggests that cold weather may be a factor influencing the

Table 1

Beginning of Construction and Date of Occupancy of Roosting Nests

Nest	Date begun	Occupied
76A	July 3	July 7
1F	July 15	July 20
92C	July 22	July 23
4C	Aug. 5	Aug. 7
82A	Aug. 10	Aug. 10
1D	Oct. 4	Oct. 6
14B	Oct. 18	Oct. 19
73F	Nov. 8	Nov. 9
1E	Dec. 1	Dec. 1
1A	Jan. 19	Jan. 20

rate. Table 1 shows the date of beginning construction and date of occupancy of ten roosting nests for which we have sufficient data.

The average date of occupancy is 2.7 days after the start of construction. Nest 82A, begun on August 10, and occupied that same evening, was built upon a foundation which had been laid on July 29 and then abandoned. At least another day should be allowed here, making the average 2.8 days. It must not be inferred that these nests were completed at their time of occupation. Occupation usually began as soon as the nest cavity had been rounded and outlined somewhat overhead. It was hardly more than a shell at this time, with a lattice of grasses for a roof. The outside finished appearance was attained at the end of 7 to 10 days. The lining of the interior took longer and might continue in irregular bursts of activity for several weeks.

Nest 25B proved to be a disconcerting exception. It was begun on August 31, 1952, with a few straws. The next day work proceeded so rapidly that by 9:18 a.m., when the wren stopped, the nest, although rather thin, was entirely covered over. It was occupied that evening. In this instance, the rapid rate of construction could hardly be attributed to desire for a warm roosting place. The afternoon maximums of temperature during this week reached 108°F., and the nights were far from cool. Neither does it seem probable that the wren hurried to finish work on this nest in mid-forenoon because it knew the day would be hot. Even humans have difficulty predicting the weather.

Attentiveness in the construction of the roosting nest was an extremely variable quantity. Distractions occurred frequently, stopping work for considerable periods. These distractions or interruptions did not always come from human disturbance in the vicinity. Noisy automobiles or children, of course, had their effect upon rate of nest construction. Other wrens were often the cause of work stoppages. It was not unusual for the builder to leave his unfinished nest to join the small territorial group of wrens that roamed the area in search of food. Perhaps it was time for a "coffee break" anyway, but it could have been a natural, aggressive tendency to seek a share of the food supply which the neighboring wrens had located.

Nest 23A, watched on August 17, 1941, revealed the following active periods, beginning at 7:20 a.m. (construction on this nest had doubtless started earlier than this). The wren made 18 visits to the nest in 14½ minutes, then it was absent 5 minutes, after which it made 21 visits to the nest in 18½ minutes. Our observations were interrupted at this point for nearly 40 minutes. Then beginning at 8:38 a.m. the wren made 9 visits to the nest in 10 minutes, stopping at 8:48 a.m. No further building was done until 5:05 p.m., when the bird returned and resumed work, finishing at about 5:30 p.m. We found this nest occupied in the evening.

Nest 25B, mentioned earlier, was watched from 8:36 a.m. to 9:18 a.m. on September 1. H-56 tapered off its morning work as follows: it made 6 visits to the nest in 8 minutes, then it was absent 14 minutes. After this it made 5 visits to the nest in 5 minutes, then it was absent 12 minutes, after which it made 3 visits to the nest in 3 minutes. Work now ceased for the day.

Nest construction began with the placing of material at the far, inner end of the space chosen among the cholla twigs. When available, the dried, stiff stems of the buckwheat (*Eriogonum tricopes*) were used at first, then small tufted grasses such as *Tridens pulchellus* and *Schismus barbatus* were used. Both of these are abundant species in the area. The buckwheat formed a framework to which smaller bits of material could easily be secured. The first part of the floor went down upon the spiny twigs; this was followed by a gradual filling in of the back, until a slipper-like toe evolved. Now and then the sharp, dense spines would apparently get in the way, for the wren pulled and yanked in an attempt to break them. At no time were wrens observed to break off the spines

preliminary to the actual installation of nest material. Eventually the floor reached a thickness sufficient to cover the spines. Their removal would thus appear unnecessary. By the time the roof of the nest cavity was outlined, the location of the entrance became evident. At first, material might be brought in from the top or sides or front. Once, after placing some grasses on the floor, a wren left the nest by climbing through the newly installed roof. Soon, however, the nest took the shape of a wide-mouthed jar, sloping down inwardly and facing outward. Short grass stems, two to three inches in length, were poked directly into place with the bill, after which the wren turned and pushed with its body in several directions, packing the material in and at the same time widening the nest cavity. Sometimes it turned completely around and used its feet to scratch the loose material farther back. The end of a longer grass stem would be trampled and anchored to the floor, then the remainder would be fashioned into the wall and roof, the wren standing upright, reaching to the roof and poking the stem into the required curvature.

As work proceeded, the nest grew in shape and size from the inside. The cavity expanded and its walls became denser and thicker with the addition of shorter bits of grass. The lining normally consisted of finer grasses, small feathers and some plant down; the latter, in this locality, was chiefly the pappus from the achene of the desert broom which matures in late autumn. The vestibule, originally about three to four inches in its outline dimensions, was filled from the inside and lengthened to a neat cylinder of one and one-half inches bore, with walls perhaps an inch thick. This tube tapered rather abruptly to its entrance. The outside of the nest came to appear more and more as if the larger grasses had been wound around it. Only at the entrance do the grasses protrude unevenly. Frequently, it was the panicle end which had been pulled in, leaving the larger, stiff end exposed. As the vestibule lengthened, it might drop to a horizontal position or even slope downward or sideways as it followed the direction of the doorstep twig. It was not unusual to find the vestibule almost incased in the spiny twigs of the cholla. No wren could enter a nest without leaning forward and practically crawling through the tube. Even so, its back must be scratched at times (fig. 5).

All of the foregoing applies to the construction of nests before the neighborhood grew up into a crowded residential section. Nests in later years were built of any available materials that could be found in the vicinity. These new materials were seldom as satisfactory as the old. Nests became larger, more ragged in appearance, and they lacked the firm, woven texture of the earlier ones. Heavy rains might collapse them, and thrashers had little difficulty in tearing them apart. In general, their useful life was shorter. The lining, now entirely of chicken feathers, often virtually filled the nest cavity. Indeed, some nests were merely thin pouches stuffed with feathers.

It was seldom necessary for the wrens to search far for nest material. Frequently such material was available immediately below and within a radius of 15 to 25 feet of the nest. In spite of the abundance of man-made trash, there was evidently a strong compulsion to build first a framework of long grasses and weed stems. Wiry Bermuda grass (*Cynodon dactylon*) runners and the thin, long, much-branched culms of mesquite grass (*Muhlenbergia porteri*) were pulled and jerked until broken off; then these were carried singly to the nest. Shorter pieces might be close by, but the longer ones were selected first, even at the expense of considerable effort. Often the effort was so vigorous that when the stem snapped, the wren tumbled backward, unable to balance itself with its spread wings and tail. Smaller bits of material were gathered up from the ground until the bill would hold no more. As construction proceeded the quest for material broadened. Wrens have been seen carrying lining material from as far as 200 feet.

Cactus Wrens were not averse to taking material from old damaged nests, but the

parts used were chiefly scraps of the lining. Apparently grasses for the exterior could be obtained more readily from the ground. Old House Finch (*Carpodacus mexicanus*) nests sometimes provided cotton-like shreds for lining. We have no records of any Cactus Wren tearing down one of its own nests, either one just begun or an old one, in order to use the same material to construct another nest in a different location. The pieces of a nest, abandoned in its initial stages of construction, were never transported to another site.

During the first few days of construction the actual time spent in the nest arranging the material was very brief. The average time for 18 visits to nest 23A on August 17, 1941, was 7.6 seconds. The minimum time was 4 seconds, the maximum 15 seconds. Another wren, working harder and longer, on nest 25B, on September 1, 1952, devoted from 15 to 30 seconds to inside work. This latter nest was noticeably farther advanced in construction at the end of the first two days. The lining requires more time to arrange. Perhaps the urgency is not as great, once this stage has been attained, for the nest is now in use at night. A minute, or even occasionally as much as two minutes, were recorded, before the wren came out. Perhaps the builder was simply resting comfortably inside while the lining settled into its proper place.

Various observers have tried to determine what external factors, if any, influence the direction of the nest entrance. Bailey (1922:167-168), working at the base of the Santa Rita Mountains, arrived at no positive conclusion. In table 2 are shown the directions faced by 100 nests of all types on the Kleindale Road area and 189 nests of all types on the Santa Rita Experimental Range.

Table 2
Direction Faced by Nest Entrance

Direction	Kleindale Road	Santa Rita Experimental Range
N	8	33
NE	12	16
E	19	21
SE	5	13
S	24	33
SW	11	23
W	11	28
NW	10	22
Total	100	189

Evidently there is no preference as to the direction in which the nest is faced. Prevailing winds on the Range are from the southwest; in the Rillito Valley they come from the northwest. Although a wren would doubtless be more comfortable facing the wind, there is no evidence here that the wind is of any importance in the position of the nest entrance. Nest construction usually begins in the early morning when wind is absent or very light. The location of the entrance is decided upon at the very start, for it faces the direction from which the wrens bring the material into the nest. In the Rillito Creek area the wind is usually from the east in the morning, and it is rather gentle. It gradually swings south, then west, and by mid-afternoon it has reached northwest, where it remains, somewhat stronger, until dusk. Heavy, dusty winds in the spring may be either from the east or west, and they often last two or three days and nights. Nests are not begun at this time, for the material blows away.

Cactus Wrens are peripheral nesters. The nest, when placed in a dense jumping cholla, is almost always at the outer surface of the crown, the entrance pointing outward from the cholla. A wren does not climb through the branches to get to its nest. If it approaches from a direction opposite to the entrance, it will invariably fly in a circle and enter from the outside, or it will land on the top of the cholla and fly down to the nest. There are good reasons for this behavior. First, it would be difficult and discouraging to drag the sometimes long and intricately branched grasses and weed stems through the maze of spiny cholla twigs and branches to a nest facing the interior. Second, and this may be even more important, the outward-facing entrance provides a greater field of view and a quick means of escape in the event of approaching danger. Cactus Wrens experience no trouble in climbing about in the spiniest of chollas, but they move slowly. Were it necessary to dash suddenly out of a nest and then through several feet of cholla twigs to reach flight freedom, the probability of impalement would be very great. In the less spiny cane cholla, where the side branches are fewer, or in the older jumping chollas, whose lower joints have been lost, nests are frequently placed close to the trunk or at the ends of the stems. In such cases, any horizontal entrance would then face outward and away, for there are no obstructions in front. Once a nest site has been chosen, convenience, accessibility, and safety dictate the position of the entrance. The best direction is outward (fig. 5).

SONG AND CALL NOTES

Many of the early observers had difficulty in describing the Cactus Wren's song. Heermann (1853:263) began by reporting the wrens "uttering at intervals a loud ringing note." Others, apparently having no first hand information of their own, repeated this statement in later publications and then made various confusing and contradictory additions of their own. More recently, Woods (*in* Bent, 1948:229-230) said that "the voice of the Cactus Wren has rather a deep, throaty quality, sometimes becoming almost a croak. The bird uses a great diversity of notes, some of them grating or ratchetlike, varied with jay-like squawks and occasional cries suggesting the plaintive demands of young birds. While foraging, a softer clucking or croaking note may be given at intervals . . ." Song "is the rapid repetition of a single staccato note. The quality of this note varies, but never in the same series . . . The most tuneful utterance that I have ever heard from these Cactus Wrens was a warbling song given by an immature bird, a song so soft that it could have been heard only within a distance of a few feet." Finally Brandt (1951:184) approaches a more complete and accurate account as follows: "incessant, mechanical singing . . . a succession of sharp, staccato notes, as though he were scolding . . . 'riv-riv-riv-riv' notes, always in the selfsame key and so rapidly one could not count them audibly. The series ran from 8 to 12 notes with a considerable pause between each group." Another wren sang "from 12 to 18 notes in each run . . . Close by there is considerable roughness and harshness in its voice, which, however, becomes mellowed by distance and loses its mechanical rasping . . . In addition . . . [there is] a series of coarse, scolding notes similar to those of the House and the Long-billed Marsh wrens, which is entirely unlike the territory song."

Thus it was nearly a hundred years after the report by Heermann of the discovery of the Cactus Wren near Guaymas, Sonora, before any accurate description of its song was published. Even then many important details were overlooked. The characteristic and distinct group of sounds other than song that frequently are uttered by the wrens has been mentioned only in general terms, and the purpose of these call notes has apparently never been studied.

Song.—By song we mean the vigorous vocal expression that coincides with the estab-

ishment and maintenance of a Cactus Wren's territory. It is never musical in the ordinary sense, for it is harsh and frequently grating. It is a series of staccato syllables, the first three or four uttered in a low tone, the next few reaching a steady, greater amplitude. This level is then held to the abrupt stop at the end, the entire song lasting only about four seconds. After a pause of from 4 to 8 seconds, the series of 10 to 12 syllables is repeated, and so on, again and again. It is difficult to assign an initial consonant to each syllable, if indeed there be one, but the vowel can be *ä*, short *a*, *i*, or *u*. The *r* sound is very strong, even suggesting the grinding of pebbles among one's teeth! Perhaps the best wording would be *char-char-char-char-char* or *rar-rar-rar-rar-rar*, the vowel varying in different songs and birds to *ä*, *i*, or *u*. Occasionally a short 3 or 4 syllable song is heard.

In singing the wren elevates its bill only slightly above the horizontal. Most of the drawings in the literature depict the wren with its bill far too close to the vertical. The song is produced with such vigor that the feathers of the throat stand out and quiver from the internal vibration. It is loud and penetrating and is easily heard at a distance of a thousand feet. As Brandt reported, distance removes some of the harshness, giving it at times a sort of ringing quality.

Buzz.—This danger note is a true buzz of varying intensity. It could doubtless easily be duplicated by means of an electrical buzzer. It may be low and persistent while the wren is following a cat or a Roadrunner (*Geococcyx californianus*). It can become a frantic, louder, half-screech if one approaches the nest and handles a frightened nestling.

Tek.—This warning call is a rapidly uttered staccato series: *é-é-é-é-é-é*. The vowel may change to short *i* or *u*. It is usually given when the nest or fledglings are in mild danger, being succeeded by the *buzz* note as the threat increases. At first, the syllables may be far apart, sounding like *check* or *tek*, then they lose the consonantal sound as the series gains momentum. Some times this call suggests the *put-put* of a gasoline motor-driven pump in the distance! Outside of the nesting season it may serve partly as a location call, although sometimes we suspect it may be used as a warning to intruding wrens.

Rack.—This call seems to be for the purpose of locating the position of the mate or other wrens. It is sometimes the first note uttered when a wren comes out of its roosting nest in the early morning. The initial *r* sound is very strong here, and it is rather prolonged, suggesting the beginning of a growl. The vowel sound is often varied to long *e* instead of short *a*, producing *rrreeek* instead of *rrrack*. Two or three calls, deliberately uttered, with a short pause between, are all that one usually hears at a time. However, sometimes, as though in excitement, a series of six or more may be given, the last part with increasing tempo. Occasionally the note is modified to a sharp *tirrip* or *turrip*.

Scri.—This peculiar, scratchy note occurs chiefly during territorial boundary disputes. It has a very rough, harsh effect, almost impossible to describe except by comparing it with the sound produced when a metal-strip rake is dragged rapidly through loose gravel. Several of these calls are usually uttered as the dispute begins. They also occur during the fight and pursuit.

Growl.—This note is part of the recognition display. It sounds exactly like the thing the name defines—a distinct growl, in which the *r* sound predominates. It may be described as *rrraawrr*.

Squeal.—The purpose of this seldom heard sound is obscure. It is uttered by the male in the vicinity of his nest, before a breeding nest has been started or completed. The female is always near by. The sound has a very painful quality, but there is no evidence of any physical injury.

Peep.—Nestlings emit faint *peep* notes.

Dzip.—Fledglings have a quickly uttered *dzip*, *dzep*, or *dzup* given singly at short intervals.

ESTABLISHMENT OF TERRITORY

Territorial assertion, if not present earlier, must begin at least in January, for it was in this month that wrens other than the pair gradually disappeared. By February 15, a pair was usually in complete possession of its breeding area. Both sexes assisted in this clearing out process. The pair which had frequented our lot and the adjoining one to the west in the course of the preceding year seemed to dominate the situation. Others might crowd in in late fall, but eventually they would be forced to vacate. Obvious fighting was rarely evident. Rather it was the persistent, nagging movement toward other wrens, sometimes leading to active chasing, that brought about the expulsion of the undesirables. These threatening runs and chases were observed most frequently in January, 1942, when six wrens were present in the area.

At the beginning of the year, HM-23 and HF-30 had the "legal" rights of occupation by virtue of earlier possession. HM-37 and HF-38 moved out in the first week and settled nearby in the northeast just outside the territory of the dominant pair. H-36, endeavoring to remain, carried nesting material to a hole under the eaves of a neighbor's garage. It was chased frequently by the resident female, HF-30. These chases usually occurred when H-36 approached the nest hole with some chicken feathers, and they seldom extended more than 10 to 30 feet. Afterward no antagonism was evident as the wrens foraged on the ground. Nevertheless, the effect of the interference seemed to be cumulative. If other wrens were in sight, H-36 appeared more and more fidgety and nervous as it approached its roost. Once HM-23 dashed toward it as it landed on the garage roof, driving it off, but generally his mate was the more aggressive. On January 4 a brief fight occurred on the ground near the garage, but the action was so swift and confused that it was not possible to trace its cause or course. When the two wrens separated to a distance of 20 feet, HF-30 was holding a piece of cotton or a feather in her bill. Two days later, HF-30 was seen clinging to the garage wall, attempting to pull out some of the projecting nest material from the eaves. Meanwhile, H-36 buzzed in protest from a safe point about 50 feet away but did not offer to defend its roosting place. On the 16th it was found dead on the ground just beneath the nest opening in the garage. Whether it had been attacked and killed by the other wrens, or by the English Sparrows, which also roosted under the eaves, or died from natural causes, we were unable to determine.

The remaining outsider, HF-35, held out until the middle of February. On January 3, HM-23 was observed following her about in the yard, HF-35 always keeping some distance ahead. She never fought back, yet she would not leave. She continued to work on her roosting nest right in the midst of the others' territory. Once when HF-35 was at her nest, HF-30 landed in the entrance, facing into it, wings and tail spread, as though intending to block ingress. In a few moments she moved to the top of the nest, stretched her neck upward, her pose suggesting the upright, alert stand of a round-tailed ground squirrel. HF-35 waited quietly on the ground below. When the other finally departed, she resumed her work on her nest. She showed a remarkable persistence and tenacity in clinging to her bit of ground at great odds. Not only was she chased and disturbed by both HM-23 and HF-30, but her roosting nest, nearly completed, was torn apart by a Curve-billed Thrasher. She began another nest. This too, in a few days, was damaged. She began work on a third, left it, and then started a fourth nest. On the 22nd another confused fight, with squeals of pain, took place in the front yard under a creosote bush. Although the participants scattered quickly, so that again the action was left

in uncertainty, we feel sure that HF-35 had been attacked by one or both of the resident birds. Chasing continued for the next two weeks. After that HF-35 moved north-east to the catclaw growth along the Rillito, beyond the area occupied by HM-37 and HF-38. Here she found a mate. Again an element of uncertainty creeps in, for her departure could have been induced by the discovery of the unattached male near the Rillito and not by the persecution of her neighbors. She had shown abundant reserves of strong passive resistance to eviction.

A puzzling aspect of the late winter chasing was the apparent disinclination to follow it through to the territorial boundary. As previously mentioned, the chases were almost always short, seldom over 25 or 30 feet, and they often stopped quickly. A threatening run toward another wren might be as little as ten feet in length. When the threat ended by the stopping of the chase, the second bird also stopped. Usually, thereafter, both birds continued their foraging on the ground without apparent hostility. Sometimes it was hours later before another such event took place. These threatening gestures of January, 1942, occurred almost in the center of the territory of HM-23 and HF-30. The mere presence of an outsider did not always provoke a dispute. However, the construction of a roosting nest seemed to be considered more of an intrusion, and it brought forth a greater and more vigorous reaction.

The following winter, when HF-35 had again moved into the local territory, another chase was observed at our east fence. HF-35 came through the fence followed by HF-39, another female which was now the new mate of HM-23. The male wren perched in the top of a nearby cholla and did not take part in the chase. The female suddenly ran toward HF-35. The latter moved about three feet away and was again chased. This time she flew to the top of a fence post. HF-39 flew up to the next post, ten feet away, then flew directly at HF-35, forcing her to leave the post and drop to the ground. From this point she was again chased, through the fence, back in the direction from which she had come. The entire distance covered by the two wrens did not exceed 50 feet.

If any intruding male ever ventured into the territory, it must have been along the remote perimeter where we failed to observe it. We never saw a foreign male take up a singing position within the territory. The reaction which might result from such a situation remains unknown to us. Boundary disputes were frequent during the crowded years, but actual invasions were not observed. Thus the establishment of ownership consisted of evicting the females which naturally were attracted to the dominant, singing male. This work fell mostly to the resident female. The male was not always cooperative in disposing of an additional female in his territory.

The hostility, so evident toward members of its own species, did not often extend to any of the other birds which gathered into loose winter flocks around our home. There might be an occasional quarrel at the feeding table, but, as a rule, each species waited its turn according to size. The resident House Finches, English Sparrows, and Black-throated Sparrows (*Amphispiza bilineata*) gave way to the larger Cactus Wrens. If a Curve-billed Thrasher or a Gila Woodpecker (*Centurus uropygialis*) arrived, the wrens edged to the side, then returned, when they were permitted, to eat what was left. Even when nesting activities began, the tolerance of other species continued. Numbers of wintering White-crowned Sparrows (*Zonotrichia leucophrys*), Brewer Sparrows (*Spizella breweri*), and Lark Buntings (*Calamospiza melanocorys*), which frequented the territory from October to late April, were ignored. In early spring, Brewer Sparrows, House Finches, and even Curve-billed Thrashers sometimes roosted in the chollas which contained occupied wrens' nests.

Coincident with the harassment and eviction of all other wrens, except his mate, was the increasing frequency of the territorial song of the male. Singing to be sure, occurred

to some extent on practically all days of the year. It was lowest in November and in the first half of December. A fresh winter rain, or above normal temperatures in the latter part of December, produced a noticeable increase at once. By January it was evident that ownership of the territory was being advertised. We were never fortunate enough to observe the first arrival of a male on a vacant territory and his immediate endeavor to establish residence and obtain a mate. In our area, at least one pair was always present during every winter of this 20-year study. Since the male already had a mate, his singing must necessarily have been almost exclusively for the purpose of proclaiming ownership of his land. As such, it did not always have the fervor and intensity of the song that might characterize his search for the replacement of a lost mate. Apparently the song is stronger when a female has not yet been secured.

Singing began before sunrise, even on cold, frosty mornings. It was not unusual to hear a few songs during an early morning rain. Sometimes singing started spontaneously, but in most cases it was in answer to a song by another wren in an adjacent territory. Seldom did these songs overlap. After each song there was a pause of sufficient length for the wren to listen to the other's song before beginning another of his own. It could be called antiphonal singing, but it was performed by two rival males, not by the male and female of a pair. Of course, if a third singing male was within earshot, overlaps became inevitable.

At awakening, singing always preceded the search for food. After a preliminary *rack* call note, there was a series of songs from perches close to the nest. Once, to our surprise, as a nest was being watched, the male uttered his first song from inside the nest just before coming out. Early in the season songs were few in number. Later, 25 to 30 or more songs might be sung before feeding began. The male sang from most of the available perches in his territory, such as creosote bushes, chollas, mesquites, roof-tops, radio antennas, windmills, and electric power poles and wires.

The singing stations were most numerous in lots 6 and 7, where the roosting nests were usually located. They decreased noticeably along the perimeter of the territory. At the far boundaries no singing at all was observed, although conspicuous elevated perches were present. In other words, the maximum territory extended somewhat beyond the singing stations and the boundaries were not advertised by means of song. Infrequent singing occurred to the north and east. This area, reaching as far as Greenlee Street and to the edges of lots 1 and 10, was, nevertheless, utilized for food and nest materials. South of Kleindale Road, the ten acres of uniform creosote bush were occasionally visited by the wrens, but they were seldom advertised as acquired territory. As previously mentioned under roosting nests, the center of activity was confined principally to the southwest corner of the tract. There seemed to be a definite reluctance to frequent the area west of Flanwill Street where chollas were few in number. As shown in figure 7, the singing stations during January and February of 1944 were grouped chiefly in a semicircle east of cholla number 6.

PAIR-FORMATION

Unfortunately it has not been possible to obtain any exact data on pair-formation. The first meeting of a male and female was never observed. When an adult disappeared, another took its place. The introductory ceremonies must have been very brief, for we were seldom aware of the substitution until it was complete. Nevertheless, from later observations, we believe it is possible to offer a probable explanation of what actually takes place at this important time. To the human eye the sexes of the Cactus Wren are identical in coloration and size. We doubt if any external character is a factor in pair-formation. Behavior then must be the key to sex discrimination and subsequent pair-

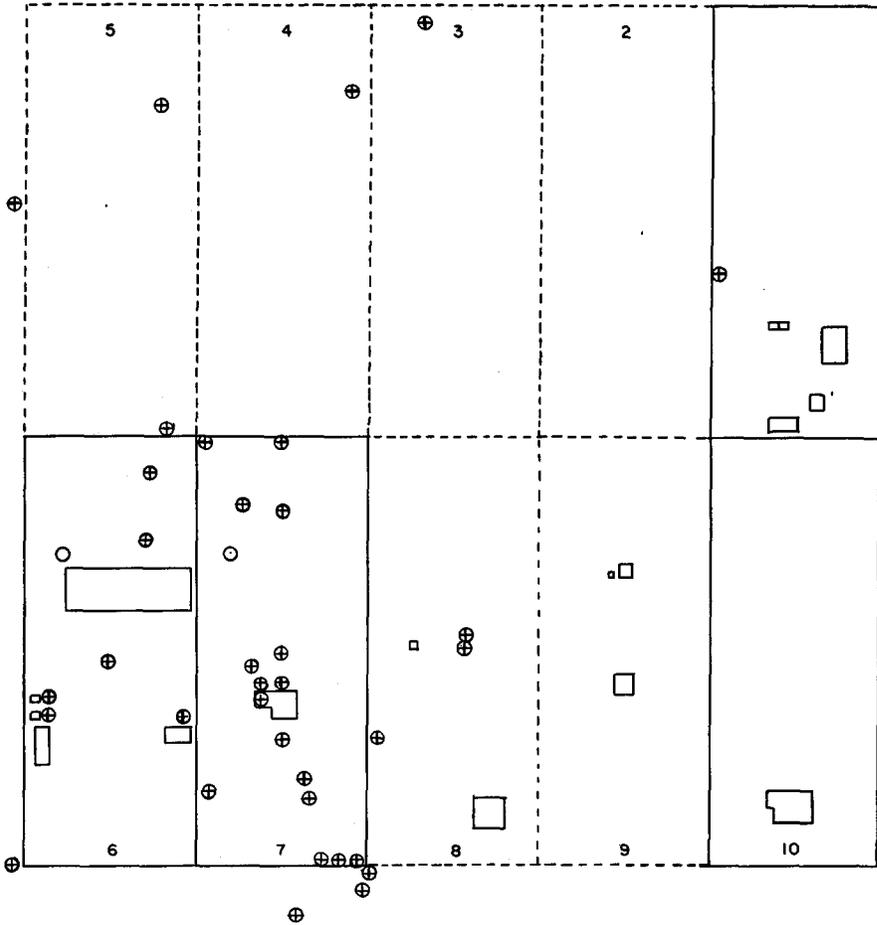


Fig. 7. Singing stations of HM-23 in January and February of 1944. Circles indicate roosting nests; crossed circles show singing stations. Cholla number 6 is in lot 6.

formation. This view is not original; it has in the past been applied to other species of birds. We have four possible situations where the element of recognition is involved.

First.—Male meets male. The loud, persistent song of the male, announcing his ownership of the territory, serves as a warning to other males. They respond by similar songs from their own staked-out territories. These songs can be considered as a part of an aggressive, hostile act, somewhat similar, at least in effect, to the barking of a dog as it threatens the coming postman. Singing usually increases as two males approach their common boundary. If the conflict erupts into active chasing or physical combat, the singing may temporarily stop, to be replaced by the scratchy call note, but, as the rivals retire, it is again resumed. When male meets male in the spring, we can assume that they will sing, then quarrel. In human analogy, of course, the singing is vocal intimidation or warning. Whatever the intent of the song, it would seem illogical to suppose that the effect is solely hostile. The song is admirably suited to the recognition of sex, for it is a distinctive form of male Cactus Wren behavior.

Second.—Female meets male. In this case the song alone would be sufficient for sex

determination on the part of the female, for the female does not regularly sing. When at times she does sing, the song is weaker and often at a slightly higher pitch. Observation readily reveals that the female is attracted to the vicinity of a singing male and frequently flies to him.

Third.—Male meets female. This is a more complex situation. If a female trespasses, we can assume there will be no song to identify her. It would seem natural for the male to fly toward the intruder to settle the matter of identification at once. What occurs then is probably what we have recorded time after time when a male flies to a female that is already paired to him. We have designated it as "display-growl." As the male arrives, for instance, on a fence post on which his female is perching, he spreads his wings and tail in a threatening gesture, uttering meanwhile a growling sound. This sound may be of one or several short syllables. The female also displays at the same time in a similar manner, then she usually crouches. She possibly growls also, but the display is so rapid that the sounds often seem simultaneous. The duration of the display is only two or three seconds. The female is the first to return her wings to normal. The male retains his threatening posture a moment longer. He may then poke his head under her chin or peck under her tail. Sometimes he pecks her lightly on the head or rump. Occasionally, as she crouches, she pecks his toes. In all cases observed, the attitude of the male was one suggesting dominance. The female cringed. As the display ended, the female usually flew down and searched for food on the ground. The male remained a while on his perch as though on guard. The most obvious conclusion is that the display is a threat. The response of the other wren determines whether there is a conflict or friendly submission. In other words, the response reveals the sex. These displays occur throughout the year. They seem to be a necessary form of greeting between the male and female of a pair during the period of active territorial ownership. They reveal the probability that the male is unable to recognize his own mate except by testing her each time they meet. This may be an extreme view to take in regard to recognition. The alternative is to suppose that continued association with the one female gradually softens the challenge of the display to a ritual assisting in pair-bond reinforcement. The challenge may become a greeting, under the continued, stereotyped submission of the female.

Fourth.—Female meets female. The female probably recognizes another female, not as one of her own sex, but as one which does not attract her. There is no song to follow or display to which to respond. The effect is neutral, until a conflict develops in relation to a male. Then the more aggressive female drives the other female out of her territory.

It seems safe to conclude that the pairing bond is accomplished rapidly and without elaborate, lengthy ceremony. Briefly, a female Cactus Wren is attracted to a singing male. He immediately threatens her. Her submissive response is all that is required for pair-formation. From then on they remain together.

The above is, of course, an ideal, simplified explanation, drawn by inference from our observations of the behavior of the wrens after they are paired. We have, at least, been certain of the sex of many of our local wrens. The behavior of color-banded individuals has been studied at length. The question of which is male and which is female is easily answered at the time of copulation, for the wrens at this time are typically avian in their behavior.

The four possible situations, which we have outlined, apply only to the meeting of two individuals. Where several wrens are present, variations are to be expected. If all the females were at the same stage of the breeding cycle and were equally "attracted," it could be assumed that all would fly to a singing male and take part in the display. In our area this did not always occur. During the prolonged period of attempts at eviction of HF-35 by HM-23 and HF-30, in the winter of 1942, we did not observe any

displays by HF-35 and HM-23, nor did we ever see the female, HF-35, fly to the male when he sang. True, we could have missed such events, for our observations were often interrupted and discontinuous. Yet, the behavior of HF-35 suggested that she was usually in a cowed, intimidated state, unable to attempt courtship. She was not equal to her rival. In fact, she could be considered third in the peck order.

Where females were equally attracted toward a male, their behavior was sometimes more difficult to follow because of the multiple action. In the several cases observed, we can assume that the process of pair-formation was at least going on, if it had not already been accomplished. On December 21, 1952, H-62 sang a number of times from the top of an electric power pole at our east fence. HF-57, which had perched on a wire a few feet below H-62, tried twice to fly up to the other, but it was gently pecked each time, until it dropped back and clung to the side of the pole. It finally flew to the ground. Fifteen minutes later, HF-58 tried the same approach, but it, too, was pecked. H-62 remained with us only a short time. Its sex was not known, but it behaved like a male. In the above case H-62 was apparently not ready to choose a mate. The absence of a display in this instance makes this a troublesome deviation from the "ideal" situation pictured when male meets female. Perhaps it can best be explained by the fact that the male had both females in his field of view at the time. There was no sudden appearance to justify a threatening posture. Furthermore, at this time, the group of wrens in the area had not yet chosen definite territories.

Later, on December 25, 1952, a more extended affair occurred about 10:30 a.m. in lot 4. There were four wrens in a cholla. Although the entire action could be observed, the birds were unfortunately too far away for positive band identification. The three in the lower part were attempting to climb up to the fourth, which perched on the top twig. One of the lower ones, carrying some small grasses, tried twice to reach the top. The display-growl could be heard several times. Then the top wren flew westward to another cholla, followed by the others. The leader uttered a *tek* sound frequently and twitched its wings and tail. Meanwhile, the other wrens moved upward, causing more displays and growling sounds. They never actually reached the top, for the cholla twig afforded room for only one bird. The displays and movements were rapid and difficult to follow, and they were even more difficult to note down in order. The group moved from cholla to cholla, westward about 200 feet, stopping at least eight times, and repeated the same behavior in each cholla. At the last cholla, the leader sang. Immediately the other three wrens climbed up, causing more displays. Only one explanation seems possible here. Three females, which were equally advanced in sexual development were attracted to this one male. Evidently territorial intolerance was slight, for only a single brief chase was observed in one of the chollas during the entire action.

On January 3, 1953, another singing wren, a noband, attracted two females to the same electric pole at our east boundary. Again, twitching of wings and tail and general fidgeting occurred, and again one of the wrens was pecked until it left. On February 14, 1953, HF-58 flew to a cholla in which HF-57 was climbing about. At once the latter wren spread its tail as though threatening, but there was no further evidence of warning. They both began searching for food in separate directions.

The season was slow in 1953. The first breeding nest was not begun until March 1, and, at this time, wrens were still undecided about their territories. Females apparently outnumbered males. Singing by females was more frequent than in other years. It often confused the work of identification. Evidence of the male's reluctance to drive out other females, or his inability to recognize his own, was provided on the evening of March 6. HF-57 and her noband mate displayed and growled from cholla number 5 in the north part of lot 7. Five minutes later the male sang from a mesquite in lot 8. Then HF-57

sang several times from a post in lot 6, after which she retired in her roosting nest, 21B, just north of our house. Soon HF-58, an unattached female, began singing from lot 6. Noband male appeared at the unfinished breeding nest 25C, located 85 feet north of nest 21B, and uttered a peculiar squealing or whining sound. He may have been disturbed because his mate was not occupying the nest which he had helped to construct. Then HF-57 arrived and the display-growl occurred. Both then flew to the pole on which HF-58 had been singing, causing the latter to move on to the electric wire. Noband male *teked*, while HF-57 twitched; HF-58 moved three feet away. HF-57 moved closer, but HF-58 remained, although she had stopped singing. HF-57 flew back to her mate. There was a brief growling sound, then noband continued *teking*, with HF-57 still fidgeting. Suddenly HF-58 flew north to the ground, followed quickly by the other two. There was chasing on the ground among the creosote bushes about 50 feet north of the fence; then scratchy sounds were heard. HF-57 returned to the pole and sang a number of times. She then flew northwest about 200 feet to another pole and sang repeatedly. Her noband mate flew to the first pole and also sang.

Evidently, at this stage the male was able to keep track of and maintain recognition of his mate, for he did not fly to her. Soon HF-57 flew back to her nest 21B and retired again. Meanwhile, noband flew northeast to a cholla where another wren had sung briefly. Here again was the display-growl, but the new female could not be identified. It may have been HF-58, for this wren now appeared in front of nest 25C. It made some low sounds and seemed disturbed as it peered into the entrance. At once, HF-57 arrived. There was a sharp growl as both birds dropped to the ground out of sight behind the cholla. Soon afterward, HF-57 sang again from the pole in lot 6, then she retired in nest 21B. By this time it was quite dusky and the other wrens had become quiet.

To summarize, noband male displayed with two females; HF-57 left her roosting nest twice in the evening, once to drive HF-58 away from the territory, and once to protect her breeding nest from HF-58. No further data on this triangle could be secured, for both HF-57 and HF-58 disappeared in the course of the next few days. The noband male, or another one, paired with HF-59 soon thereafter, then both completed nest 25C for their breeding nest.

The wing and tail twitching, accompanied by the rather slowly uttered *tek* note, apparently did not occur often in the early years of this study. We suspect it is more prevalent when there is a surplus of females. Both sexes take part. The male reacted in this manner when confronted by two or more females. The female reacted similarly when she was faced with competition. It is probably a form of threat behavior, although to the human eye it suggests nervousness.

SUMMARY

Cactus Wrens were studied over a period of about 20 years in the vicinity of our home near Tucson, Arizona. By means of color bands it was possible to trace their activities with considerable success. This first paper deals with their winter territories, roosting nests, song, establishment of territory, and pair-formation.

The study area consisted of a creosote bush association with an irregular sprinkling of cholla cacti. Streamside vegetation of catclaw and mesquite was also present.

Cactus Wrens remained in the vicinity during the entire year. No evidence of migration could be found, nor was there any flocking behavior. A pair of wrens, with some birds-of-the-year and a few outsiders, usually formed a loose group and occupied an area of approximately 15 acres in the winter.

All of the wrens required a covered roosting nest in all months of the year. When no old nests were available, the wrens built new nests. Cholla cacti were commonly used for

nest sites. Male and female nests of the resident pair were seldom far apart; they were sometimes in the same cholla. The usual design was a pouch with an entrance at one end. This form was "standard," but the materials varied with what was obtainable in the locality.

Difficulty in choosing a site was sometimes evident by the beginnings of nests that were never completed. Construction of a roosting nest might begin at any time of the day, but once started, work began early each following morning. Nests were occupied from one to six days after construction began.

Nest entrances faced outward from the cholla, evidently for ease in entry and quick escape if necessary. Prevailing winds were not a factor in determining entrance direction.

The song is a simple, oft-repeated series of harsh sounds. There is a danger note, a warning note, a possible location note, and a boundary dispute note. A growl is heard during the recognition display. Nestlings and fledglings have begging notes.

Territorial intolerance began at least in January. By February 15 the area was usually cleared of other wrens. Females were most active in driving out other females by chasing and fighting. The male apparently kept out other males. Singing by the male increased as the territory was secured. Singing stations were most numerous in the vicinity of the roosting nests.

Since the sexes are identical in coloration and size, sex discrimination must be by means of distinctive behavior. Pair-formation has not been observed, so we can only conjecture at this point from the behavior of already paired birds. Males can, no doubt, recognize other males by means of their songs. Females are probably attracted to males upon hearing the song. When they meet, there is a threatening display by the male, including the spreading of his wings and tail, accompanied by a growling sound. The female also displays and then she crouches. A female thus reveals her sex by cowering. These displays occur throughout the year and suggest the assumption that the male cannot recognize his mate at the beginning of the season except by threatening her each time they meet. Later the display may become a ritual aiding in maintaining the pair-bond. Females probably recognize other females as such only when they are in conflict over a male.

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