BREEDING OF THE STARLING IN CENTRAL ARIZONA

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The Starling (*Sturnus vulgaris*) has become established since 1954 as a common breeding resident in the Phoenix area of central Arizona (Monson and Phillips, A checklist of the birds of Arizona, 1964). This is not surprising in view of the character of the habitat available. Phoenix and several smaller cities lie in the Salt River Valley, a large, irrigated farming district. The Salt River Project, which serves a major portion of the Valley, provides water for 238,000 acres, including 160,000 acres under cultivation and 50,000 acres classed as residential. Cotton, alfalfa, grains, grapes, lettuce, and citrus are important crops. Starlings forage in fields and on lawns, and feed on cultivated fruits. In fall and early winter, flocks feed and loaf in large cattle feedyards. Good roosting sites are available in small cattail (*Typha* spp.) marshes. Taller oleander (*Nerium oleander*) hedgerows, old, untrimmed citrus groves, mesquite (*Prosopis juliflora*) thickets, and fields of tall, dense forage sorghum (*Sorghum* sp.) also serve as seasonal Starling roosts. An abundance of trees suitable for nesting is, however, the factor most directly accountable for the large breeding population. Descriptions of nesting sites and breeding habits presented in this paper are based on observations made from 1961 to 1964 in the Salt River Valley.

From 1962 to 1964 I used boxes of the Ithaca design (Kessel, Amer. Midl. Nat., 58:257–331, 1957) to obtain information on the reproduction of the Starling in Arizona and to establish a banded population of known age. Dates of laying, clutch and brood sizes, and egg and nestling losses were the principal data recorded.

On 14 February 1961, 50 boxes were placed on trunks of Washingtonia palms (*Washingtonia filifera*) along a one-mile sector of Litchfield Road in a cropland area two miles south of Litchfield Park. The elevation is 1030 feet. At Mesa, 28 miles east of Litchfield Park and 1225-feet elevation, 50 boxes were placed on shade trees and poles within a semirural area of approximately one square mile, which includes the 160-acre University of Arizona Experiment Farm. The boxes at Mesa were put up between mid-December 1961 and 20 February 1962, and were taken down in July 1962. On 11 March of the following season only seven boxes were set up on the Mesa study area while 90 boxes were used along Litchfield Road because these could be more easily inspected. All boxes were placed on the palm trunks on 14 and 15 February along a 1.5-mile sector that included the 1962 one-mile study area. In 1964, 10 boxes were placed along Litchfield Road on 2 January, and 11 boxes were used at the Mesa Experiment Farm. Six of the latter remained from the previous season and five were added on 5 February. I removed the Litchfield Park boxes on 27 April when the outcome of all first broods was known.

NESTING SITES

Mature hardwood trees are common in older urban areas, around farmsteads, and along many roads in the Salt River Valley. Many contain Gila Woodpecker (*Centurus uropygialis*) holes and natural cavities. Starling nests were found in cottonwood (*Populus fremontii*), Chinaberry (*Melia azedarach*), peppertree (*Schinus molle*), and Chinese elm (*Ulmus parvifolia*), in April and May 1961–1962.

Giant cactus or saguaro trees (*Carnegiea gigantea*) are common near Scottsdale. On 3 April 1962 four pairs of Starlings and one pair of Gila Woodpeckers were nesting in a single large saguaro tree containing about 14 woodpecker holes.

Starling nests were found in crowns of Washingtonia palms and date palms (*Phoe-*

nix dactylifera). When a highway crew trimmed off several years' accumulation of dead leaf fans from hundreds of Washingtonia palms along a section of road at Litchfield Park in the spring of 1961, it found numerous active Starling nests at the base of leaf petioles but above the mat of old growth. During late morning on 20 April 1961 I counted 129 adults and 14 fledglings along one mile of this road. During the next two breeding seasons Starlings showed a preference for untrimmed palms. During three mid-morning counts of adult Starlings, 1 to 8 April 1963, along a mile of road, an average of 51 birds was seen in untrimmed palms along one side of the road and an average of only 10 birds was seen in trimmed palms lining the opposite side. When several palms were retrimmed in the spring of 1964, two active nests were found in each of two palms.

REPRODUCTION

Nest building and related behavior. Between 27 February and 21 May 1961, 100 adult male Starlings were collected near Mesa. When taken, most were singing, displaying, or inspecting nest sites. All were in breeding condition, gonads averaging 14.3 mm in length (range, 11 to 18 mm). On the morning of 19 April 1962 I heard a Starling singing inside a nest box at Mesa. It was not at the entrance hole but out of view, probably on the floor. This is the only time I observed such behavior. A very little nesting material in this box dated from 3 April, and no further nesting activity took place until 25 May.

Boxes were readily accepted by Starlings on both study areas. Nest building was first observed at Mesa on 16 February 1962. By 2 March, 26 Mesa boxes contained nest material. However, the first egg did not appear in at least 28 boxes until from three to nine weeks (mode, 4 weeks) after presence of nest material was first noted. I did not seek earliest dates of nest building in 1963 and 1964.

Egg laying. Kessel (*op. cit.*) calculated that egg laying began about 15 March for the earliest North American Starling brood then on record. In the description of nesting sites, I reported four Starling broods in a saguaro at Scottsdale on 3 April 1962. I judged from the hoarseness of their cries, and the brief appearance of a nestling at one hole, that the young in two broods were about two weeks old. If this estimate is accurate, and if one backdates 12 days for incubation and four days for egg laying, the two earliest clutches were begun about 5 March. These are the earliest broods found in four years of field work.

Adult Starlings fed two strong-flying fledglings at Mesa on 19 April 1961. Allowing four days for laying, 12 days for incubation, and 21 days for growth in the nest, this brood was begun approximately 13 March. This is the earliest brood encountered at Mesa. In Mesa nest boxes the first egg-laying began on 24 March 1962, 25 March 1963, and 24 March 1964.

At Litchfield Park the 1961 laying season began at least as early as 14 March, calculating back from the 20 April observation of 14 fledglings. The first eggs were laid in nest boxes on 29 March 1962, 9 March 1963, and 21 March 1964.

Kessel (*op. cit.*) stated that "in a given locality the majority of the Starlings in a population begin egg laying each year within 3 to 4 days of each other." She also stated that only a few scattered clutches are laid in the "intermediate" period between peaks of first-brood and second-brood laying. The large samples at Mesa in 1962 and Litchfield Park in 1962 and 1963 show a similar but less peaked pattern in this region than in the Northeast. Arizona first- and second-brood layings each extend over a 10- to 25-day period. There are fewer clutch starts per day in the intermediate

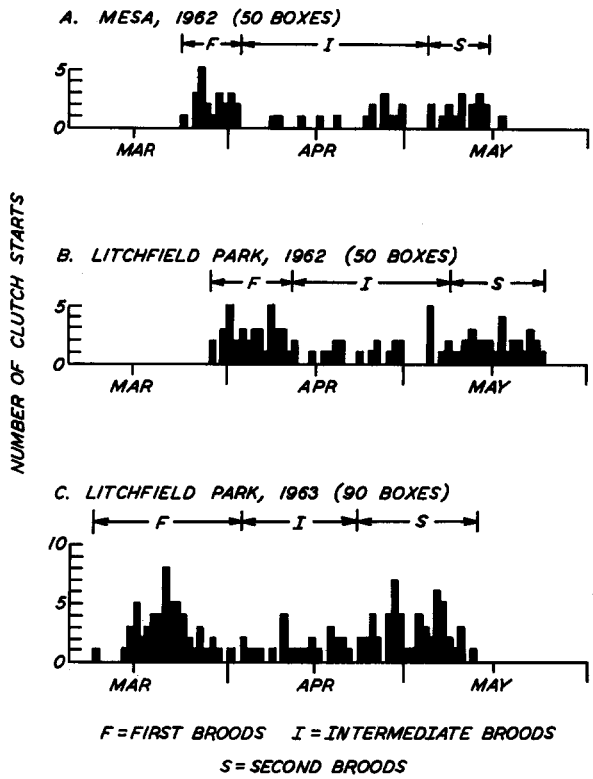

Figure 1. Dates and numbers of Starling clutch starts in nest boxes. One clutch begun 18 April 1963 was a second clutch as it was in the same box as the clutch begun on 9 March and fledged about 12 April.

period than in the first- and second-brood periods, but intermediate-brood layings still comprise a significant proportion of all layings. Figure 1 shows schedules and rates of egg laying in nest boxes in 1962 and 1963.

It is noteworthy that while the first Litchfield Park clutch in 1963 was begun 20 days earlier than the first one on the same study area in 1962, the last 1963 brood was begun 13 days sooner than the last one in 1962. The total length of the laying season thus varied only one week, and the first 1963 clutch accounts for five days of this variation. About 40 days elapsed between the layings for first and second broods. The latest clutch start at Mesa was on 28 May 1962. A clutch, begun at Litchfield Park on 3 June 1962, is the latest nesting attempt recorded during the study.

Temperature data from the Litchfield Park weather station for January through March, 1961–1964, are shown in table 1. The early advent of laying at Litchfield Park in 1961 and 1963 may be a result of unusually high average daily temperatures in late winter. Daily mean temperatures between 15 and 28 February 1963 averaged 59.7°F compared with 52.0 for the same period in 1962. Between 1 and 15 March 1963 daily mean temperatures averaged 57.8 compared with 51.9 in this period of 1962. Only six first-brood clutches are represented in the 1964 data, but laying began later than in 1963, following subnormal temperatures for Litchfield Park in February and March.

TABLE 1

TEMPERATURE DATA, LITCHFIELD PARK WEATHER STATION, JANUARY THROUGH MARCH 1961–1964*

Temperature characteristic	Year	January	February	March
Mean Maximum Temp. (°F)	1961	71.5	74.7	77.9
	1962	67.4	71.0	72.8
	1963	66.6	78.3	77.7
	1964	65.8	69.1	74.0
Mean Minimum Temp. (°F)	1961	38.9	40.9	43.7
	1962	35.8	41.0	38.4
	1963	32.5	44.2	43.2
	1964	32.0	32.3	41.5
Mean Temp. (°F)	1961	55.2	57.8	60.8
	1962	51.6	56.0	55.6
	1963	49.6	61.3	60.5
	1964	48.9	50.7	57.8
Departure from normal (°F)	1961	4.7	3.2	0.8
	1962	0.8	1.3	–4.7
	1963	–1.2	6.6	0.2
	1964	–1.9	–4.0	–2.5

* From Climatological Data, Arizona, monthly reports, Weather Bureau, U.S. Department of Commerce.

At the Mesa Experiment Farm temperature data were similar to those for Litchfield Park every season. Early laying for 1961 broods, as evidenced by fledglings on 19 April, followed above-average daily temperatures in late winter. Perhaps earliest laying at Mesa in 1963 was not truly reflected by the small sample consisting of only five first broods. Or late (11 March) placement of boxes may have been selective, the earliest breeders having already established their nest sites elsewhere. No weather data are available for Scottsdale where the early 1962 broods were discovered in a saguaro. The cactus was located at the edge of 25 acres of undisturbed desert. This site, with a relative humidity probably lower than that of irrigated areas, may have a higher average daytime temperature. This could stimulate earlier egg laying.

Time and interval of egg laying. In three seasons 22 clutches appeared to contain eggs not laid at the usual one-day interval. In these clutches one egg preceded or followed (usually the latter) the remainder of a clutch by two to nine days. There may have been prior miscounting in some cases, as eggs sometimes were partially buried in nesting material. Or, another female could have laid a stray egg in such a nest. Twenty clutches were laid on an apparently abnormal schedule at Litchfield Park; seven were concentrated in one sector of the study area in 1962, and the oddity was repeated in the same box in successive broods on two occasions.

Clutch size. Arizona Starlings averaged 4.4 eggs per clutch in 285 complete clutches. At Mesa, 78 clutches averaged 4.7 eggs, and 207 Litchfield Park clutches averaged 4.3 eggs. An analysis of variance showed these averages were not significantly different at the 5 per cent level. Frequency of occurrence and mean size of complete Starling clutches by brood periods on each area are shown in table 2. The eight-egg clutch was among those apparently laid in an abnormal interval. Ten very late

TABLE 2

FREQUENCY OF OCCURRENCE OF VARIOUS CLUTCH SIZES, AND MEAN SIZE, OF 275 COMPLETE STARLING CLUTCHES

Clutch size	Mesa clutches			Litchfield Park clutches		
	First	Inter-mediate	Second	First	Inter-mediate	Second
2	0	0	0	1	1	1
3	2	1	0	8	10	13
4	13	8	9	42	18	35
5	9	4	10	27	7	24
6	6	5	3	4	3	4
7	1	0	1	2	1	1
8	0	0	1	0	0	0
Total	31	18	24	84	40	78
Mean	4.7	4.7	5.0	4.4	4.1	4.3

clutches that followed the second main brood period are not included in table 2. These averaged 3.8 eggs.

Incubation. Twelve days elapsed between laying of the last egg and its hatching. This agrees with Kessel's (*op. cit.*) data. A pair of Starlings completed a four-egg clutch on 1 May 1962 at Litchfield Park, but the eggs failed to hatch in the usual period. An adult flew from the box on 25 May, and the eggs were still intact on 29 May. Only two eggs were present on 1 June. Either one or both adults thus continued to care for the eggs for four weeks.

Nest desertion and *destruction.* Adult females were handled at 81 nest boxes. They deserted 11 of 36 nests when handled during egg laying, three of 37 nests during incubation, and five of eight nests while brooding nestlings. Nine males handled during the incubation period remained with the nest, but another male deserted four one-day-old nestlings.

Thirty-two clutches disappeared from nests before the expected hatching date. Of these, 14 nests held only one egg, seven held two eggs, and eight held three eggs at the last inspection before discovery of nest failure. In addition 20 desertions were attributed to handling, four nest boxes were believed robbed by children, and four boxes with broods were destroyed by vandals.

Egg losses and brood size. There are 170 broods for which exact brood size is known. These average 3.7 young per brood. Frequency distribution and mean size of Starling broods are shown in table 3. Intermediate and second broods are combined under the heading of "Late" broods, following Kessel's mode of tabulation. At Mesa, 44 broods average 4.0 young, and at Litchfield Park, 126 broods average 3.6 young. First broods are the largest in each area. Unfortunately, in 78 additional clutches the fate of 100 eggs is unknown. They may or may not have hatched before their disappearance during the hatching period. Because of this uncertainty these broods are not included in brood size averages and tabulations. If these are combined with the 170 broods for which complete records are available, then average brood size ranges between 3.4 and 3.8, assuming that all 100 eggs of doubtful fate failed or succeeded in hatching, respectively.

In both study areas the average brood size was 0.7 less than the average clutch size. About 110 eggs from 74 nests showed no embryo development on the expected

TABLE 3

FREQUENCY OF OCCURRENCE OF VARIOUS BROOD SIZES, AND MEAN SIZE, OF 170 COMPLETE STARLING BROODS

Brood size	Mesa broods		Litchfield Park broods	
	First	Late	First	Late
1	0	2	3	4
2	1	1	3	8
3	2	7	13	20
4	9	9	29	25
5	2	7	9	8
6	3	1	1	3
Total	17	27	58	68
Mean	4.2	3.8	3.7	3.5

hatching date. Fifty-seven eggs in 34 clutches developed, but the young failed to hatch.

Causes of nestling losses. The first week or so after hatching is the most critical period for Starling nestlings. Many weaker or last-to-hatch young die soon after hatching. Of 143 successful (that is, one or more young fledged) broods, only 26 did not suffer mortality.

Red fowl mites (*Dermanyssus gallinae*) were present on both study areas every year. I did not carefully scrutinize broods at each box inspection to learn if and when they became infested, but recorded the presence of mites whenever they were noted. In 1962 at least 11 Mesa boxes and 31 Litchfield Park boxes were mite infested. Mites were in most of these boxes in the first or intermediate brood period. Dense breeding populations of Starlings and House Sparrows (*Passer domesticus*) along Litchfield Road might explain the apparently greater frequency of mites in that area. However, I have not overlooked the possibility that I served as a vector of mite infestation when handling many broods in succession.

Among successful broods mites had little or no effect on fledging percentage. At Litchfield Park in 1962, 14 successful broods with no record of mites averaged 1.7 fledglings compared with 1.6 for 28 broods with mites. A few heavily infested broods succumbed at about two weeks of age while others fledged. About a dozen young left mite-infested boxes at about 16 to 18 days of age.

In 1963 I devoted more attention to mites at Litchfield Park. On 12 April I found a mite on my hand while checking nest boxes. Mites were on two-week-old nestlings on 22 April, and this nest was prematurely empty three days later. Mites were unnoticed in other first-brood nests until 30 April, when two nest boxes from which young had recently fledged were found covered with mites. Twenty-eight intermediate and second nestings were known to be infested during May. During April and May I used a pyrethrum-rotenone spray to test its effect on nestling survival. Limiting analysis to the 31 nests known to harbor mites, six out of 11 sprayed broods (55 per cent) were successful and fledged a mean of 2.2 young per nest, whereas eight out of 20 unsprayed broods (40 per cent) succeeded, fledging an average of 1.8 young. When all 1963 nests were considered, regardless of the presence of mites, the percentage of successful nests increased to 69 and 47 for sprayed and unsprayed nests, respectively, and the mean numbers fledged per successful nest were 2.3 and 2.2. Many

nests in both experimental groups were evidently uninfested so that spraying had no differential effect.

Spraying nests gave mite control of short duration because mite eggs are not harmed by pyrethrum-rotenone and adult Starlings may still carry mites. Seven of 22 boxes (32 per cent) sprayed before intermediate- and second-brood hatching became infested with mites. Twenty-four of 43 comparable unsprayed broods (56 per cent) became infested.

After the first-brood period of 1962 was well along, I drilled ventilation holes in nearly all nest boxes because overheated boxes were causing some egg losses. High temperature also resulted in deaths of all nestlings in at least two boxes. Some poorly located boxes were moved to shadier sites. In 1963 most of the 50 nest boxes on the east side of Litchfield Road were partly or fully shaded by cottonwoods or palm foliage most of the morning. All 50 were in afternoon shade. I placed a maximum-minimum thermometer in one of these east-facing boxes which contained an empty Starling nest. This box received full sun until after 1100, the most severe condition for any box east of the road. On 12 dates between 18 April and 20 May box temperatures, read at about 1000, averaged 88°F. Maximum daily temperatures averaged 98°F. Maximums in the box ranged as high as 110°F during May, but hottest temperatures were not attained until sometime after the morning reading and the box undoubtedly cooled again in afternoon shade.

The 40 boxes west of the road faced west or northwest and had full morning shade. By 1400 the sun cleared overhead palm foliage and struck a number of boxes that were not shaded by other trees. Seven readings were taken in one box with an empty nest between 17 and 31 May. This box was in partial shade as late as 1450, but received full late-afternoon sun. Early-afternoon readings averaged 94.6°F and ranged from 92 to 98°F. Maximum readings averaged 111 and ranged from 104 to 120°F. Another west-facing box with more afternoon shade was much cooler, as shown by two late-May maximum readings of 94°F.

The percentage of successful nests on the two sides of Litchfield Road differed slightly, 46 per cent for east-facing versus 44 per cent for west-facing boxes. Adverse effect of high temperature on nesting success is probably a factor only in nest boxes because natural cavities are much better insulated and palm crown nests are well shaded.

An incident late in the 1963 nesting season provided an interesting note on the relationship between Starlings and Gila Woodpeckers. In a nest box on the Mesa Experiment Farm on 23 May, there were five Starling nestlings ranging from one to five days in age. At 0845, 24 May, I saw a Gila Woodpecker fly from the box as an adult Starling arrived. An inspection revealed only two nestlings present, one dead and one nearly so. They were the oldest of the brood, judging from their weights. Their crowns and backs were covered with fresh punctures. All evidence points to the woodpecker attacking the brood. This was the first observation of woodpeckers giving attention to nest boxes, but on 25 May 1964, I found what might be supporting evidence that woodpeckers may attack nestling Starlings. In a box several yards from the site of the 1963 incident, three of four young Starlings appeared to have been pecked on their heads. The attack, by whatever agent, was not so well executed, however. Only one nestling died while three fledged 12 days later. On 8 June in the same vicinity, a pair of Gila Woodpeckers was occupying a nest box which had not been used by Starlings that spring. They had chipped away much of the inner surface of two walls and had laid two eggs. Although the nest was soon deserted,

TABLE 4

YOUNG FLEDGED FOR VARIOUS BROOD SIZES*

Clutch size	No. clutches	First brood				Intermediate and second broods				
		Total no. eggs	No. young fledged	Mean fledged/ clutch	Per cent fledged	No. clutches	Total no. eggs	No. young fledged	Mean fledged/ clutch	Per cent fledged
2	1	2	1	(1.0)	50.0	0	0	0	0	0
3	5	15	9	1.8	60.0	7	21	11	1.6	52.4
4	42	168	107	2.5	63.7	22	88	46	2.1	52.3
5	21	105	57	2.7	54.3	26	130	59	2.3	45.4
6	8	48	21	2.6	43.7	10	60	24	2.4	40.0
7	1	7	2	(2.0)	28.6	0	0	0	0	0

* Nestings that were failures are excluded.

the attempt to nest in a box may explain why the woodpeckers would attack a Starling brood.

Renesting. A Starling at Mesa began a four-egg clutch on 27 March 1963 and on May 12, nine days after her first brood fledged, she began a five-egg clutch in the same box. Another Mesa bird began a four-egg clutch on 25 March 1963 and began a second four-egg clutch in another nest box near the first on 7 May, six days after the first brood fledged.

Three female Starlings at Mesa in 1962 followed up unsuccessful nesting attempts with nearby renestings. One whose first clutch of the season was taken from the box on 20 April (after failure to hatch) was captured on 1 May at a tree-cavity nest with three eggs. Another whose first brood fledged on 3 May deserted five eggs after being handled on 18 May. She began a three-egg clutch on 27 May. A third Starling was caught 11 May in a tree-cavity nest containing five fresh eggs (probably her second clutch). After deserting this nest, she began a clutch of five eggs in a nest box on 17 May. In these instances, re-laying began six to nine days after desertion.

A review of Litchfield Park records for 1962 reveals that, whether a particular nest box produced fledglings or failed, the next clutch was begun most frequently from six to nine days after the box was vacated.

Nesting success. The following figures on nesting success are presented with the knowledge that they do not necessarily give a true picture of the breeding success of Starlings in this area. Considering the several factors discussed above which bias the results of the nest-box study toward either greater or lesser nesting success, I suggest only that the data might show the approximate success of the species in this area. There are no data for broods raised in natural nest sites with which to compare the nest box data.

There were 29 nest failures resulting from human interference. Of the remaining 299 broods studied, 143 were successful. An average of 2.4 young fledged from each successful nest. The egg-to-fledging success for these nests is 52.3 per cent. At Mesa 58.8 per cent of the eggs fledged, and at Litchfield Park, 49.6 per cent. First broods were more successful than later broods, with 57.1 per cent of first-clutch eggs and 46.8 per cent of intermediate- and second-clutch eggs fledging.

Nesting success in relation to clutch size is shown in table 4 in the form used by Kessel (*op. cit.*). There were only six clutches, each of four eggs, in which all eggs hatched and fledged. Four young, the most fledged from any brood, were raised only 19 times. In nine nests, each with a known hatch of six young, all nests lost young

birds within six days of hatching, and losses occurred in eight of these nests within three days of hatching. There are 40 nests with a hatch of five or six. Thirty-seven of these had losses within a week. Five young survived in three nests through the ninth, tenth, and eleventh days, respectively, but each lost one nestling within one to three days thereafter.

Nest sanitation. As broods approach fledging age, nests in boxes may become dirtier than those in palm crowns and in some natural cavities. Most nest cups in the Arizona boxes are too far below the entrance hole to allow nestlings to eject their droppings directly out of the hole. Many natural nest cavities, on the other hand, are located in inclined tree trunks or limbs where young birds can easily back up to the entrance hole.

Among successful nests, parent birds most frequently removed dead nestlings from the nest when death came during the first nine days after all young were hatched. From then until fledging, dead young were commonly found in the bottom of the nest under the surviving young. Several dead young were found below boxes, but evidently many were carried farther away. I may have introduced a bias in favor of survival of remaining nestlings by removing dead young at every box inspection. In many cases the nestlings had been banded and I wanted as many as possible to fledge.

BAND RECOVERIES AND OBSERVATIONS

Eighty-nine adult Starlings involved in nest box studies wore the U.S. Fish and Wildlife Service leg band and a blue plastic leg band; 341 fledglings wore a Service band and a white plastic band. A number of other banded nestlings disappeared from nests at too early an age to have had much chance of surviving. Through June 1964 another 435 Starlings were captured at roosts, cattle feedlots, or in natural nest cavities. They were released with a Service band only.

Fourteen band recoveries and sightings of color-banded Starlings indicated that Starlings of all ages may be permanent year-round residents in the Salt River Valley. Some bred in the locality in which they were raised, and some adults remained in their nesting localities at other seasons. A juvenile male that was banded at an oleander roost five miles east of Litchfield Park on 25 July 1952 was collected 18 miles east of there at a cattle feedlot on 9 March 1964. This was the greatest distance between points of banding and recovery or observation.

Among 12 Starlings collected at a feedlot west of Glendale on 24 February 1964, two birds possessed thick fat deposits in the intestinal cavity. This suggests that some birds migrate from central Arizona as the breeding season approaches.

SUMMARY

Starlings were studied during their breeding season from 1961 to 1964 in the Salt River Valley of central Arizona. Data on natural nesting sites and breeding population densities are presented. With 100 nest boxes, breeding data were obtained at Litchfield Park and Mesa. The Starlings studied began 328 clutches. Dates of first egg laying ranged from 9 March to 29 March; first laying occurred earlier in years in which average daily air temperatures in February and early March were highest. Each year two well-defined brood periods began about 40 days apart, but some laying took place in the intermediate period between them. Arizona Starlings averaged 4.4 eggs per clutch in 285 complete clutches. Brood size averaged 3.7 for 248 clutches that hatched. Data on nesting success and causes of egg losses and nestling mortality

are reported. Band recoveries and sightings of color-banded birds provided information on Starling movements in the Salt River Valley.

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