Notes on Nests and Behavior of the Hawaiian Crow[1]

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AMONG THE SCANTY WRITINGS on the Hawaiian crow (*Corvus tropicus* Gmelin), there is no detailed record of its nest and eggs or of its habits associated with the breeding cycle. Berger (in press) lists and reviews the literature and reports that the current total population of this species may be as small as 25 birds. This present paper describes the final example of use by crows of a traditional nesting ground on the lower northeast flank of the Hualalai volcano, Hawaii County, Hawaii, in 1964. A nest discovered under construction on March 26 was observed at intervals of 6 to 9 days, through April 26, when it failed; a single infertile egg remained from the original clutch of five and the crows were then in the process of abandoning the nest.

DESCRIPTION OF HABITAT

The nest area is a xerophilous native forest (annual rainfall about 60 cm) at an elevation of 730 m, about 0.8 km above the Mamalahoa Highway, in the Puuanahulu Game Management Area. The exact location is 3.1 km east, 6.0 km north of Puuwaawaa, a prominent cinder cone of the region. The substrate here is the undated Kaniku flow of rough aa lava containing uncovered pockets (kipukas) of an earlier pahoehoe flow. These flows all spread in a northwesterly direction from distant flank eruptions of Mauna Loa. Hualalai is a relatively old mountain that was last active in 1801; now it is apparently dormant.

Ohia (*Metrosideros polymorpha*) and lama (*Diospyros ferrea*) are the dominant trees of the area and form a relatively continuous forest on the pattern of older aa flows. Mature trees are generally 5 to 12 m tall. The ohia is often as tall as 12 m, tends to have a spreading canopy, and the trunk may be made up of one or several stems. Lama reaches heights of 4 to 6 m and is usually dense and bushy. Both species appear to be slow-growing but well adapted to the site. One obvious characteristic of both trees is brittleness of the wood. Branches as large as 7 cm can be readily snapped off and are, therefore, undependable for rests in climbing.

A third prominent plant is fountain grass (*Pennisetum setaceum*), an aggressive African tussock grass that is dominant in the forest understory. It provides abundant ground fuel and, hence, promotes its own increase through fires that destroy other species. The ancient pahoehoe kipukas are now covered solidly with fountain grass and support few trees, apparently because of fires that have raged over the land since the accidental introduction of fountain grass about 1920. This grass is less able to invade the rough aa, where there is little soil, but may still be scattered over about half the surface of the aa. Fires in September 1960, before my observations, and in August 1969, both seriously reduced the acreage of endemic forest available to the crows by killing segments sufficiently undergrown by the grass.

OBSERVATION

Crows were reported along the highway adjacent to the nesting area by several observers as recently as the early 1960s. Dr. Glenn E. Haas, who suspected that nests might be found in the area, urged that we search for one. Neither of us had actually seen the crows, nor were there recent reports of them on March 26, 1964, when the search began. Working in from the highway through the ohia-lama forest at 8:20 A.M., we came within 20 minutes upon two crows moving about and foraging among the trees and, at times, on the ground, in one of the small kipukas that contained a few trees. We watched the birds for a time, but they retreated ahead in mild alarm when approached

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within 35 meters. Unhurriedly following the direction of their travel up the lava flow and listening for their occasional calls, we found the birds again at 9:44 A.M., engaged in construction of the nest designated in this paper as nest no. 2. Data gathered during the sporadic study of this nest, and in subsequent observations, are reported in the following pages by topic rather than in a strictly narrative account. I was accompanied on each trip to the nesting area by one or two other persons who acted as observers, but all information gathered was entered in my own field notebook.

Summary of the History of Nest No. 2

March 26—nest under construction; large sticks and twigs carried.

April 4—nest essentially complete but birds still lining it.

12—four eggs yolk-stained from a fifth broken egg; birds incubating.

18—incubation continuing; nest activity watched for 5 hours.

26—birds incubating, but restless; single remaining egg inviable.

Nests and Nest Sites

The nest area, as defined by a belt of rather continuous forest in which five nests were found, was about 1 km long, extending in a northeasterly to southwesterly direction between the broad expanse of the 1960 burn and the 1859 lava flow, from an elevation of 720 to 740 m. Four of the five nests were old ones from previous years. All were in ohia trees, and were generally built where the largest trees occurred in clusters with adjacent glades. They were constructed of coarse sticks, and the linings that remained were of stems and blades of grasses, a few small twigs, and some lengths of slender vines. Nests were placed in forks near the tops of trees, supported each by two to four branches that divided repeatedly to form the leafy canopies of the trees. Elevation above the ground ranged from 6.5 to 10.6 m.

Nest no. 1 was discovered on March 26, 1964, as the crows were followed from the point of original sighting toward the active nest no. 2. The site was about 275 m west of nest no. 2 and the adjacent nest no. 3, near an arm of the 1960 burn. This nest was starkly visible in the crown of a fire-killed ohia, supported in the fork of a limb 8 cm in diameter, 7 m from the ground, and 1.2 m from the top of the tree. Except for the loss of leaves and bark, the tree had deteriorated little in the warm, dry climate. The nest was in good condition, but weathered gray like the skeleton of the tree. It may have been in use at the time of the 1960 fire, or shortly before. Width was 50 cm, depth 20 cm, and the twigs were generally not greater in thickness than 6 to 10 mm. The nest lining was deteriorated, leaving a bare cup 20 cm wide and 9 cm deep. From below, light could be seen through the remaining structure of loose sticks.

Nest no. 2 was 8.2 m above the surface and about 1.5 m from the top of a tree whose single sloping trunk was about 45 cm in diameter. The nest was supported by three branches and a large twig of a limb 7 cm thick, measuring, respectively, 5.7, 5.0, 5.0, and 2.2 cm in diameter. Many leafy proliferations of these branches formed a segment of the dense upper canopy above the nest. Width of the nest was 45 to 48 cm with some twig ends projecting beyond this general periphery. The nest cup was 19 to 20 cm across, leaving a platformlike rim about 12 cm around it. Total depth was 24 cm and the lined cup was 7 cm deep. The lining was of stems and blades of fountain grass interwoven with the flexible strands of huehue (*Cocculus ferrandianus*), particularly about the periphery. The lining formed a separate unit easily removed from the supporting framework. About a third of the total bulk of the nest was dissected in detail after the birds had abandoned it; the entire lining was preserved. There were 57 twigs of ohia, 20 of lama, and eight strands of huehue in the segment of the framework studied. Of the 77 sticks (both species combined), 61, or nearly 80 percent, were branched; the remaining 16 were unbranched. Lengths ranged from 13 to 57 cm, and the mean was 31.9 ± 2.22 cm (2 SE). Diameters ranged from 2.5 to 11.8 mm and the mean was 6.6 ± 0.37 mm. The eight strands of huehue were highly variable in length, ranging from 20 to 150 cm, with a mean of 79.3 ± 41.34 cm. Diameters were uniform, ranging from 1.5 to 2.3 mm with a mean of 1.9 ± 0.64 mm.

Arthropods, but not including fleas, were extracted from this nest and its lining (Tomich, 1967).

Nest no. 3 was located in a tree whose crown adjoined that which supported nest no. 2, and was about 4 m from this nest. Nest no. 3 was 10.6 m above ground, slightly higher than nest no. 2, but supported in a similar fashion at the branching of a stout limb, 1.5 m under the leafy canopy of the tree. Apparently this nest had been constructed and used 1 or 2 years before 1964. Its lining was almost all gone, but the substantial frame of the nest remained.

Nest no. 4 was a remnant old nest found on April 4, 1964, about 60 m south of nest no. 1. Height above ground was approximately 6 m. No detailed description was made of the nest or its site.

Nest no. 5 was discovered on January 30, 1965, in the upper branches of another ohia killed by the 1960 burn. This site was about 60 m west of nest no. 1 and some 350 m west of nests nos. 2 and 3. It was more in the open than the others, about 30 m from the denser tree clusters, beside a grassy kipuka near the western edge of the nest area. The nest was supported by three branches diverging from a limb below the twiggy canopy of the tree, 6.5 m above the ground.

Nest Construction

Construction of nest no. 2 was well advanced when it was discovered on March 26. Both members of the pair were active in carrying twigs and in adding them to the nest platform. Nest-building was a desultory affair, frequently interrupted by foraging expeditions, resting, and other diversions. It is likely, as in other corvids, that *Corvus tropicus* builds its nest over a protracted period of several weeks rather than in just a few days. Indeed, the 1964 pair was off foraging some 600 m from the nest when first encountered, but, when again in view about an hour later in the vicinity of the nest, they were probably in the general process of building. At 10:04 A.M., as we identified the nest tree, a bird flew toward us and into the crown of an ohia only about 10 m from the nest. The second bird came to a nearby snag and then flew to the top of the same ohia tree. The lower bird plucked a dead, branching twig about 30 cm long and hopped out of sight into the dense foliage. The second crow flew off and the first one reappeared without its twig, picked a smaller one, dropped it, and flew off after its mate. Obviously, the birds had been disturbed by our presence but we now settled down some 20 m away from the nest tree and waited. The crows were heard calling occasionally from a distance of about 60 m, off among the trees.

After 27 minutes one bird came directly to the nest tree, and was followed immediately by the other. Each bird carried a twig and lit among the branches below the nest. One fluttered and climbed to the nest platform, followed by the other, and both worked their twigs into the nest structure. As one continued to work after 7 minutes, the other flew to the adjacent ohia and lit 2 m below the old nest no. 3. From there it took a perch directly beneath this nest and tugged at a stick. When the stick did not come free the crow worked its way up beside the nest, was able to wrestle a different twig from the rim, carry it in flight to the new nest, and work it into the nest structure. Meanwhile its mate had stopped working and had flown to the old nest but did not attempt to dislodge a twig. After a period of about 2 minutes of rest and preening beneath the new nest, both birds flew off silently, low among the trees, at 10:47 A.M. The work session had extended for 16 minutes.

The birds were away from the nest for 13 minutes before they returned and soon continued work. Apparently they had been foraging, because one bird carried food which it ate or dropped, out of our sight. At 11:02 one bird flew to the nest with a twig, and the other seemed to be plucking one from the adjacent tree. In our observations the birds plucked clean, dead twigs and sticks from the trees and did not take any material from the ground surface. After 4 minutes, this bird also flew to the nest tree, made four leisurely hops from limb to limb, and finally climbed to the nest taking about a minute. Both birds then worked at the nest, but at 11:08 one flew to a nearby perch and looked about. Then it flew to the crown of a lama 12 m away, plucked a leafy

cluster, and returned to the nest. At 11:11 one bird flew off as the other continued to arrange nest materials, but when the nest bird was called by its mate after 3 minutes, it also flew off. After 6 minutes one crow returned with a twig, but the other remained perhaps 60 m away. Occasional calls were exchanged as one bird worked at the nest for about 3 minutes; then it left to join its mate. At 11:25, after an absence of 2 minutes, a crow arrived at the nest with a twig, again hopping from limb to limb from below to reach the nest rim. It soon left the nest in response to calls from its mate, and the birds apparently left the area or were quietly at rest. This session of building with only one bird, perhaps the same one, at the nest lasted 16 minutes. The entire second session, from 11:02, extended for 23 minutes. When there was no further sign of the birds after 20 minutes, we quietly left the area without attracting their attention.

On April 4, with one observer, I searched the region in and about the nest area for nearly 3 hours, but found no signs of crows other than the remnant nest no. 4. At 11:00 A.M. we went near nest no. 2 and settled in a makeshift blind at the base of an ohia approximately 18 m from the nest tree. At 11:30 the crows arrived in file, passed low among the trees with an audible rush of wings about 5 m from our blind, and proceeded directly to the nest tree. The first bird carried a small object in its bill (presumably lining for the nest) and immediately mounted to the nest rim. The other bird perched first about 2 m below the nest; it then hopped and flew up to join its mate. One bird was in the nest forming the lining and the other remained on the rim. After 3 minutes the birds rested for about 2 minutes in their respective positions. Then one flew off to a lama about 10 m away, followed by the second bird. Here they perched, facing one another, on horizontal branches about 2 m above the ground and quietly preened themselves and one another. This action was leisurely. Presently one bird moved to join its mate on the same perch. Here they sat side by side and the grooming continued. The rest period ended at 11:49 A.M., after 14 minutes, when one bird roused and hopped into a dense portion of the tree, out of sight. After 2 minutes it flapped against the foliage of the tree in launching and flew to the nest. The second bird followed the same route, carrying a piece of soft nest material, such as a curled blade of grass. One bird worked in the nest and the other was on the rim, but we could not discern details of their activity. After 7 minutes both birds were quiet, then both were on the nest rim, one walking about. At 12:02 P.M., after 12 minutes at the nest, one bird swooped away and disappeared. The second bird continued to rest for another 10 minutes, then it walked up a branch from the nest, spread its tail, stretched, and flew off after its mate.

When an observer began to climb to the nest at 12:15 the birds returned, one clutching a curled, dry grass blade which it immediately dropped from a perch 4 m from the nest; the other, responding to the alarm calls of its mate, carried nothing. The nest lining appeared to be ready for reception of the eggs even though the birds were still adding materials to it. Included were both green and dry items. It was especially obvious that some unbleached blades of grasses had been incorporated. We soon retired from the area in order to minimize disturbance to the birds.

Eggs and Incubation

On April 12, 8 days after the crows had been observed completing the nest, I visited the site with two observers. A brooding bird was flushed from the nest as we arrived at 11:18 A.M. The task on this trip was to describe and photograph the nest and its contents. Four eggs present in the nest were smeared with dried yolk from a broken egg. One egg was lightly smeared with blood when laid. It is assumed that the clutch size was originally five. No two eggs were exactly the same color; however, three had a pale greenish-blue ground color and were heavily splotched with brown. The fourth had a paler ground color of grayish blue, but generally heavier blotching than the others. In addition to the blotching, which was concentrated near the larger ends of the eggs, there were relatively dense flecks and a few spots, generally in black. The eggs were, therefore, in color and in pattern, much like those

TABLE 1

NUMERICAL DATA OF EGGS FOUND IN NEST NO. 2

	EGG NUMBER				MEAN
	1	2	3	4	
Length (mm)	42.7	44.9	46.2	46.4	45.1
Width (mm)	29.0	30.5	30.2	29.1	29.7
Ratio (%)	67.9	67.9	65.4	62.7	65.9

of other genera and species of corvids. Numerical data are given in Table 1.

It was impossible to know when incubation began, but if an egg had been laid daily from April 5 through April 9, it could have been as early as April 9.

On April 18, approximately on the 8th day of incubation, accompanied by one companion I made 5 hours of observations, beginning after daylight. An attempt was made to reach the nest and settle down near it before daylight, but the exact location could not be found by flashlight. We began watching from the partial blind consisting of jumbled aa, tussocks of fountain grass, and a fallen limb at the base of an ohia 18 m from the nest tree. Both birds were vocal and active in the vicinity as we arrived and settled, but only one was seen in the dim light at the nest when the watch began at 6:45 A.M.

This bird soon left the nest, hopped up into the foliage about a meter above, rocked and fluttered, and then returned to brooding. The tail of the bird projected above the nest rim and usually indicated its location and position. The second bird was then seen at rest on the far rim of the nest. After incubating for 12 minutes, the nest bird shifted about 90 degrees. Four minutes later the resting rim-bird flew off 15 m to another ohia, returned below the adjacent old nest, preened briefly, and then flew 15 m in another direction to a lama, where it appeared to be foraging. Soon it returned and was identified again at rest on the nest rim. It soon became obvious that both birds shared the incubation, that the bird not sitting on the eggs at a particular time was highly solicitous of its mate, and that the birds sometimes preened one another. At other times the off bird sat quietly on the nest rim or rocked from side to side, dozing. It may be postulated that the nonbrooding bird spends the night on the nest rim because of the usual use of this resting platform during the day and the lack of any specific resting perches away from the nest. Changeover is frequent and the eggs are almost always attended by one or the other of the pair. Frequent trips are made away from the nest by one bird, and, for short intervals, both birds are absent.

At 8:00 A.M. the off bird was on the nest rim, vigorously preening, with one wing raised. Preening continued for about 2 minutes. At 8:05, after resting, this bird stood, shook and fluttered slightly, and flew off. The sitting bird arose and followed, but only to the adjacent lama tree; it then returned in slow stages from 4 m below the nest, to resume incubation. It was absent only 40 seconds. Its mate returned 10 minutes later, having called several times from some distance away. There had been no alarm. At 8:16 there was a definite changeover when the brooding bird arose slowly and flew off, and its mate slipped from the nest rim into position over the eggs.

Because of the similar appearance of the birds and because of our lack of knowledge of which bird was which after both were out of sight, we found it to be impossible to distinguish between the sexes. Some details of the nest activity were obscured by foliage and branches. Conditions improved when, at 8:23, I climbed from the makeshift blind to a vantage point near the level of the nest, causing minimal disturbance to the crows. Figure 1 is a record of 5 hours' observation of the nest.

Self-preening by the bird at the nest rim was often continuous for several minutes, especially about the neck and breast, with wings somewhat raised and feathers loosely fluffed. Mutual preening also occurred frequently. At 9:17 the brooding bird held its head high as its mate sat on the nest rim. There was occasional bill preening between them; then the nest bird settled again. Five minutes later the birds were again billing. Then the nest bird twice probed gently, with bill open, at the head of the rim bird. It then rose from the nest cup, briefly ruffled its feathers, and flew off silently. The

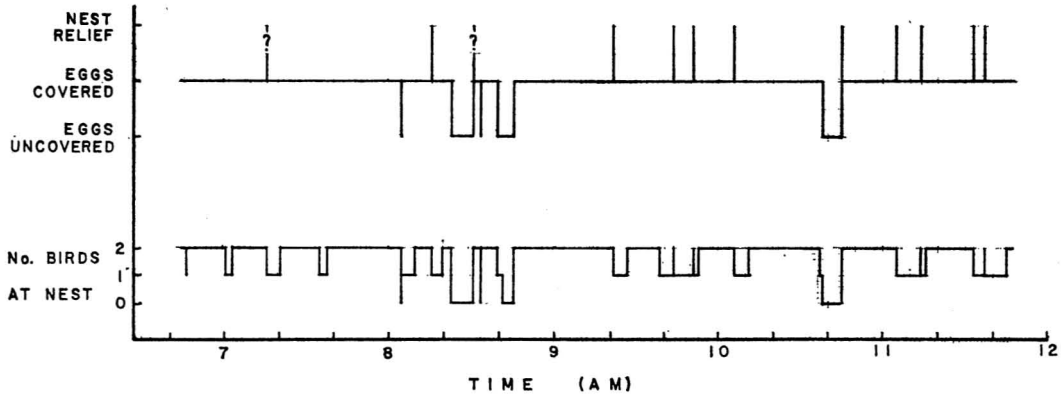

FIG. 1. Record of nest attention by a mated pair of Hawaiian crows on April 18, 1964, about the 8th day of incubation.

rim bird reached into the nest as if turning or arranging the eggs, leaned into the nest with wings and tail slightly ruffled, and then settled onto the eggs. This behavior required about 20 seconds, and was in contrast with the usual immediate settling of the relief bird.

Nest attention was somewhat casual with one bird leaving or returning at will and the other usually at hand to take over, even if just for a few minutes. At 11:16 the off bird returned to the nest rim, stood for nearly a minute over its brooding mate, then settled down with a rocking motion. When settling on the nest rim or into the nest, the birds often made this side-to-side motion as if placing the feet comfortably. After 3 minutes the off bird preened intermittently for 12 minutes, standing several times and then settling each time. Then it stood attentively with its head down as if urging its mate from the eggs. At this, the brooding bird flew off and the relief bird immediately settled on the nest.

With one observer, I visited the nest again on April 26, on about the 16th day of incubation. At 10:00 A.M., while we were still 100 m off, we heard excited calls of crows from near the nest. These calls were repeated in series several times during the next 9 minutes. When we circled and approached the nest from the forest above it, a crow that was apparently on a foraging trip 60 m from the nest and 30 m from us, ignored us. When we were in the close vicinity of the nest tree at 10:29, a crow flew from a perch in an ohia 12 m away to the nest, also seeming to ignore us. Several low calls came from the nest. We settled down under our observation tree at 10:36. One crow on the nest rim seemed to watch us idly, while the other remained in the nest, but neither expressed alarm.

After 6 minutes of quiet the rim bird stood up and soon flew off to an ohia 10 m away, perched 3 m above ground on a horizontal limb, pecked at the bark, ran 3 m along the limb, and then flew back underneath the nest as low calls were made by the brooding bird. It idled in the tree for nearly 4 minutes, then rose in a hopping flight on a usual route to the nest rim. There it settled, preening. The disturbance in progress 45 minutes earlier seemed to have subsided completely. A gentle wind swayed the nest as the birds idled. The brooding bird turned about in the nest at 10:56 but appeared to be completely at ease. At 11:05 the brooding bird dipped off the nest and lit in a rangy, dying ohia about 30 m from the nest. This snag had been used occasionally when one or another of the birds approached the nest or at times of alarm. The crow began to preen, then after about a minute it began to make the ringing, fluty, two-note calls we had heard earlier in the day. These were loud, expressing a quality of alarm. Usually two calls were given in succession, but sometimes these were single or in threes. These vocalizations appeared to have a special significance, so are reported in some detail. In the next 7 minutes the bird gave 20, 23, 29, 24, 26, 24, and 21 calls. In

the first minute the bird gradually ceased preening as its excitement rose, and this excited state was maintained. During the 4th minute, having continuously faced the nest, the bird then turned about and faced away from it. The nest bird seemed to ignore its calling mate until the 5th minute when it then showed alertness toward the bird on the snag. At the beginning of the 8th minute the perched bird gave one call, and flew about 60 m to the edge of a large kipuka where the birds frequently foraged. After two additional calls from the kipuka, the brooding bird left the nest, perched about 20 m away, and answered with a pair and a single one of the same kind of calls that its mate had been making. In the 9th minute the more distant bird sounded five more calls and these were answered with three calls by the bird that had just left the nest. This crow then flew off to join the other at the kipuka and all was quiet.

When the birds did not return after 9 minutes I quickly climbed to the nest. A single egg remained which was heavily stained with yolk from other eggs broken and which was infertile or had otherwise failed in development. It was then obvious that the nest was a failure and that the alarmed behavior observed that morning was part of the process of voluntary abandonment of the nest. The fate of the missing three eggs, which had not been seen since the nest was examined closely 14 days earlier, was a matter of conjecture. Apparently they had been broken, possibly in the normal nest care by the crows. The surviving egg weighed 15.6 g.

At 11:26 A.M. one crow returned to the nest in great alarm as I remained in the tree about 3 m away, at the level of the nest.

The bird brooded the empty nest only briefly and then left. First one crow and then the other (the bird which had called from about 300 m away) returned after 20 minutes. Both birds were in the tree, somewhat disturbed by my presence, and, when I took several photographs, they called almost continuously. Later, one bird again returned and settled on the nest, but both birds left as we retreated from the nest area at noon.

The unfortunate loss of the nest may be attributed to the softness of egg shells which could not withstand the usual pressures during the turning of the eggs and during incubation. A second possibility is that the roof rat (*Rattus rattus*) may have been a predator on the eggs. This rat is a common resident of the forest, but since no observations of its behavior are available, no conclusion can be drawn.

Wariness

For a crow *Corvus tropicus* is outstandingly tolerant of humans, but this is not unexepected for an insular species that evolved in the absence of significant predators and that developed no specific conflict with man's interests. The crows were only briefly disturbed at each intrusion into their nesting and foraging habitat, and quickly accommodated to our presence as soon as we settled quietly. The makeshift blind only 18 m from the nest tree consisted of jumbled aa lava, tussocks of fountain grass, and a fallen limb and the trunk of a large ohia tree. We were only partially concealed as we wrote notes, manipulated field glasses, ate lunch, and occasionally shifted about.

Several references have already been made to the responses of the crows to our activities. When encountered the first day away from the nest, the birds ignored us when we were 70 m off, but flew silently away, toward the nest, when one of us walking directly toward them approached within 35 m. On another instance away from the nest the crows, although they ignored us when we were only 20 m away, soon left the area. When I first climbed to a perch in the tree at the blind the birds were disturbed, but settled into routine activity after 8 minutes. Later, as we ascended and descended individually from the perch among the ohia branches, the crows did not obviously respond. When I examined their eggs in detail near the beginning of incubation, both birds remained in the vicinity but moved off approximately 15 to 60 m, keeping up a sporadically continuous exchange of alarm cries. Twice they came into the tree but remained for only a short period. Their concern became intensified with time.

When the nest tree was climbed on the final day as the nest was being abandoned, one, and then both, crows came to the nest with the observer only 3 m away. They retreated when

a camera was manipulated, but photographs were successfully taken. I concluded that if an observer were to remain quietly in such close proximity to the nest during normal incubation, the birds would probably adapt quickly to his presence. Further evidence that crows ignore humans and are unsuspicious of them was gained when a crow passed overhead only 4 m above, in full view of the occupied blind. The bird continued directly onward to the nest with no alterations in course or behavior.

Vocalization

Calls of the crow form an important aspect of communication between the paired birds. Although modern sonographic equipment would have permitted detailed analysis of vocal sounds as related to behavior, it seems desirable to record what was learned without these aids. Our general impression of the Hawaiian crow is that it is a mild, incurious, unboisterous version of the American crow, *Corvus brachyrynchus*. Its voice, which is generally mellow and musical, contrasts with the usually coarse and raucous calls of the American crow. The typical crow "caw" as voiced by *C. tropicus* is more like "cawk." It sounds as if it were produced from a pair of reed pipes of different tones, but has a trace of a harsh final inflection. At other times the call is a wild "ca-'wak," which may denote sudden alarm. When the birds were first encountered near the nest, apparently unaware of our presence, they gave, in 30 seconds, three "cawk" calls in sequence, which were followed by a fourth one. Then, while we were standing in the open, one bird swooped through the trees past us, uttered a sharp "ca-'wak," and flew on; then the softer "cawk" calls continued in the vicinity between the two birds.

When the pair was together in the vicinity of the nest during its construction, they uttered low, gutteral "cawk" calls while selecting nest materials. When one bird was some distance off, its mate uttered soft, reassuring "cawk" notes that called the other from the nest to join it. In one sequence, after an absence of 6 minutes by both birds, there were loud "cawk" calls; one bird returned to the nest with a twig and the other remained some 60 m away, probably foraging. It was answered only once, with an unconcerned, low, rasping "cawk" by the bird working at the nest. After 2 minutes the nest bird called once and the other answered with repeated soft calls; then shortly the nest bird left with a sharp, loud "cawk" and was answered by a similar, but lower-pitched call. After this both birds called repeatedly in low tones from that locality. This exchange demonstrated almost constant communication between the birds that apparently served not only to call them together, but to inform of conditions near and about the separated birds. A few minutes later, when one bird was distant from the nest and the other continued to work at construction, there was a vigorous exchange. The distant bird gave three forceful calls in slow cadence, "cawk—cawk—ca-'wah," as if in question. The nest bird answered somewhat more forcefully and flew off rapidly to join its mate. Nest construction was terminated and the crows appeared to leave the area.

When the crows were disturbed at the nest during completion of the lining, and at other times when we intruded closely to inspect the nest, they voiced loud "caw-'awk" calls as they flew from perch to perch in the tree or in neighboring trees. This alarm cry served to alert the mate if it happened to be out of sight of the nest, and to attract it to return; perhaps also, it reinforced response to intruders as the birds fluttered excitedly about.

When we examined the nest near the beginning of the incubation period, the birds remained nearby; when we moved over to begin observations from the blind, the birds retreated. All was then quiet for 9 minutes. There were three loud calls some distance away that seemed to be an all-clear signal; then one bird returned and quickly settled on the eggs. While arranging itself in the nest the bird uttered five or six low chuckling notes that seemed to denote tranquility. These same calls were heard on another occasion when the birds, who had left the nest as we examined it closely, returned to resume nest attention.

On April 18 at 7:20 A. M., after an absence of 5 minutes by one bird while the other brooded, the off bird sounded a low "churk" from some distance away. About a minute later it returned to the nest. When it worked up to

the nest rim from below, one low grating "cawk" was given. There was a second, musical "caw-'awk" with a prominent, ringing two-note effect. Then, immediately, there were three more usual "cawk" calls. There was some suggestion of feeding cries in this example, but it was not possible to learn if one bird had fed the other. When the crows were quiet at the nest there were occasional low, caressing "cawk" sounds. These calls were given also when the birds were together for brief periods, away from the nest.

Once, after both birds had gone to different locations away from the nest and had been calling to one another, one returned to the eggs. The second bird gave a loud "cawk" and soon arrived near the nest, intensifying its calls to the level of alarm, where it lit in a tree some 15 m from the nest. The brooding bird was alerted, stood and peered toward its mate, then flew off to the approximate location of that bird. It returned quickly to the eggs, followed by the off bird who settled quietly on the nest rim.

The loudest, most persistent, and perhaps the most distressful calls of the crows were made during the process of nest abandonment on April 26, as already described. These cries had the fluty character of more usual calls, but were forced and seemed to denote extreme anxiety.

Foods and Feeding

It was apparent that the crows, in these brief observations of nesting, were able to sustain themselves in the vicinity of the nest during its building and the incubation of the eggs. The birds were seen as far as 0.6 km from the nest and it is unlikely that they strayed much beyond this limit. Several times food was brought near or to the nest, but seldom did we observe the birds actually eating. On March 26, after being absent from their partially constructed nest, both birds returned, one carrying a large, bright, red-orange fruit, possibly a *Solanum*, in its open bill. This fruit was about 2.5 cm in diameter. From the nest the bird planed to the ground under a nearby tree, but soon it arose without the fruit. We were unable later to find the fruit. Likely it was eaten. On April 26 when nest attention was fitful and the birds restless during a short period of serene nest keeping, the bird resting on the nest rim stood up with its bill agape, holding a large red fruit, apparently of the same species as that seen before. With the fruit then deep inside its bill the bird flew off to an ohia 10 m away. At that point, the fruit had either been swallowed or dropped.

On April 12 one crow rested at the nest rim while the other covered the eggs. After 5 minutes the resting bird flew off 6 m to a lama tree where it fed on the ripe fruits, dropping one whole fruit and fragments of others. Then it returned to the nest. We did not determine if one bird fed the other at the nest. During our observations the crows several times appeared to be feeding on the fruits of lama.

On April 18, during incubation, a bird left the nest rim and flew in two stages to the tree above the blind. It landed on a large horizontal limb and, while clinging partly along the side, proceeded lightly to pry bark loose. Then it moved rapidly along the limb, audibly prying as it went. We could not be certain that this bird was actually seeking food. It flew off and 3 minutes later was back at the nest. On the same day a bird that was absent from the nest for about 5 minutes returned with a small fruit in its bill. When the bird had mounted the rim of the nest it had by then eaten or dropped the fruit.

The nest was examined closely on April 26. Bits, pieces of rind, and occasional seeds of lama were scattered on the rim. Some of these were fresh. This evidence suggests that the crows habitually bring food materials to the nest and eat them.

DISCUSSION

Other crows were absent from the nest area during this study, which demonstrates that colonial nesting is not necessarily an attribute of this species. The nests found were of several different ages and were evidently constructed and used over a period of years, possibly by a single pair of birds. Approximately annual visits to the area through 1970 revealed no activity of crows after 1964, indicating that the range is now restricted to exclude them. All traces of nests had disappeared by 1969.

The vicinity of the Puuwaawaa Ranch headquarters at 915 m on the north slope of Hualalai, and higher lands of the mountain, may be the last refuge of the Hawaiian crow. Dr. Cameron B. Kepler of Cornell University and his wife report (personal communication) that on December 20, 1965 they were attracted by calls of crows from the eucalyptus grove just above the ranch buildings. "We initially found 3 birds, one of them begging for food and calling in a shrill voice more highly pitched than that of the other birds. This bird, presumably a juvenile, could feed itself effectively. These three birds were ultimately joined by 4 others, and all 7 birds permitted very close approach—to within 15 feet on many occasions. We watched them feeding in the area for over an hour, and they were still there when we left at noon. The gardener mentioned that crows were common in the grove, and were not molested by the ranch hands." From his knowledge of North American crows, Kepler is assured that begging by the young lasts a maximum of 2 to 3 months after fledging, and concludes that the young bird he observed may have come from a nest started as late as July. Exact limits of the breeding season are unknown, but nests active in March and July would suggest a protracted period.

Jon G. Giffin, a biologist of the State Division of Fish and Game, reported that, on October 26, 1970, six crows gathered and watched excitedly, and two were calling some distance away, as he handled a live pig captured at 1,070 m on the west flank of Hualalai. Nine birds were seen about a month earlier in the same vicinity and are supposed to be the same flock. Formation of these aggregations, in spite of a small total population, seems to be a characteristic of the Hawaiian crow.

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LITERATURE CITED

BERGER, ANDREW J. In press. Hawaiian birdlife. The University Press of Hawaii, Honolulu.

TOMICH, P. QUENTIN. 1967. Arthropoda associated with a nest of the Hawaiian crow. Proceedings of the Hawaiian Entomological Society, vol. 19, no. 3, pp. 431–432.