State of California
THE RESOURCES AGENCY
Department of Fish and Game

FEEDING AND NESTING BEHAVIOR OF THE YELLOW-BILLED CUCKOO IN THE SACRAMENTO VALLEY

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Administrative Report 80-2

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ABSTRACT

In summer 1979, a Yellow-billed Cuckoo population along the Sacramento River near Hamilton City, Glenn County, California, was studied. Cuckoos foraged both in riparian vegetation and in orchards, with 88% of their food items coming from the riparian. Grasshoppers (50.7%) and caterpillars (35.7%) were the most important food sources. The foraging areas ranged from 10.8 to 28.3 ha, including 8.8 to 10.8 ha of trees, both riparian and orchard. Four nests were located, three in a walnut orchard and one along a willow lined slough. Four additional nests were believed to have been in the study area. Nesting success was 100% and fledging success was 57%. A live nestling was removed from a nest by one of the parent birds when sufficient food for all nestlings was apparently not available. Cuckoos were subject to exposure to organo-phosphate pesticides due to nest site selection in orchards. Persistent pesticide residues in three unhatched eggs ranged from 0.08 to 0.11 ppm. DDE, indicating low levels. Since orchards are systematically sprayed, severely limiting insect food sources, the extent of existing riparian habitat is the ultimate limiting factor for this species. Within the remaining habitat, food availability appears to be the main limiting factor. Nest site availability and pesticide exposure may be important secondary limiters.

Wildlife Management Branch Administrative Report 80-2
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RECOMMENDATIONS

1. Retain Yellow-billed Cuckoo on State rare species list.

2. Evaluate all studies to determine if upgrading of Yellow-billed Cuckoo to endangered species status is warranted.

3. Re-census the Sacramento Valley cuckoo population using new knowledge about nest site preference.

4. Continue acquisition of riparian habitat, giving priority to sites known to support cuckoos.

5. Consider acquisition of walnut orchards adjacent to riparian woodland. Top priority for acquisition should be the remainder of the riparian woodland near Pine Creek Wildlife Area and the walnut orchards (60.9 ha) across the river.

6. Stop bank stabilization and channelization projects, which halt the normal plant succession in riparian woodlands, and encourage research into use of willows for erosion control.

7. Stop removal of riparian vegetation in known and potential cuckoo habitats.

8. Allow riparian vegetation to grow on rip-rapped banks.

9. Encourage the development of alternative methods to control codling moths and especially walnut husk flies.

10. Consider elimination of pesticide spraying in walnut orchards near riparian areas between mid-June and mid-August.

11. Encourage use of ground spraying instead of aerial application in vicinity of riparian woodland.

INTRODUCTION

The California Yellow-billed Cuckoo (Coccyzus americanus occidentalis) breeds in California in small numbers. Formerly, it was much more common. Loss of riparian habitat accounts for much, but not all of the population decline. Studies by Gaines (1974, 1977) covered the decline of this species and censused the current population, but little is known about the ecology of the species. The primary source of ecological information is a study Hamilton and Hamilton (1965) conducted in southern Arizona and along the Colorado River. In their study areas, habitat and food supply are quite different from that found in the areas where the bulk of the California population occurs. This lack of basic biological and ecological information, along with concerns about pesticide use in orchards where cuckoos were believed to be foraging, led to the present study.

METHODS

The study area was chosen by examining aerial photos of the Sacramento Valley and locating riparian areas, adjacent to walnut or almond orchards, where Yellow-billed Cuckoos have been previously recorded. The particular site was selected because of these characteristics, ease of access to Fish and Game's Pine Creek Wildlife Area, and the presence of alternating bands of vegetation and open areas which make movement of the birds easier to detect.

Initially, I established contact with the cuckoos by using tape recorded calls and then observed them as long as possible. After some patterns of movement were detected, cuckoos were observed from strategic spots. Once the first nest was found, it was observed from a blind, and food items and behavior were recorded. After the young fledged, the activities were observed from a distance that did not interfere with the birds' activity. Another observer, when available, was stationed where he could see the birds flying into the nest site with food items. Three nests found later were observed from a distance of more than 50 m as it was not feasible to observe them from a blind.

On August 9 and 10 censuses of the study area were conducted using tape recorded "kowlp" calls. On August 3 and 4, the same method was used to survey potential Yellow-billed Cuckoo areas at Clear Lake. Cuckoos were also surveyed on five canoe trips from Red Bluff to Los Molinos.

The normal field day was from 0600 to 1500. On some days, field observation continued until dark. All censuses ended by 1400. A total of 608 hours was spent in the field and cuckoos were under observation 23.4% of the time. Away from the active nest they were observed only 7% of the time.

Chronology of Field Work

June 1 - 15	Initial contact with cuckoos.
June 18 - July 20	Found first nest in walnut orchard and observed nesting activities.
July 22 - 26	Found and observed second nest in walnut orchard.

July 27 - Aug. 8	Found and observed third nest in walnut orchard.
Aug. 3 - 4	Censused Clear Lake.
Aug. 9	Censused walnut orchard.
Aug. 10	Censused riparian area.
Aug. 10 - 23	Found and observed fourth nest in riparian area.
Aug. 24 - Sep. 10	Continued observation in orchard and riparian area.

STUDY AREA

The main study area was on the banks of the Sacramento River in Glenn and Butte counties between river miles 196.5 and 198.5, the center lying 3.6 km southwest of Hamilton City. The area (Figure 1) consisted of 109.2 ha of undeveloped land of which 52.2 ha were riparian woodland. The rest was open, either sand bars or grassland with a few scattered bushes. To the north lay an almond and a walnut orchard, with the Sacramento River to the east, south, and west. Across the river to the south and west lay walnut and almond orchards and to the southeast lay wheat fields. Originally this area across the river was not conceived to be part of the study area.

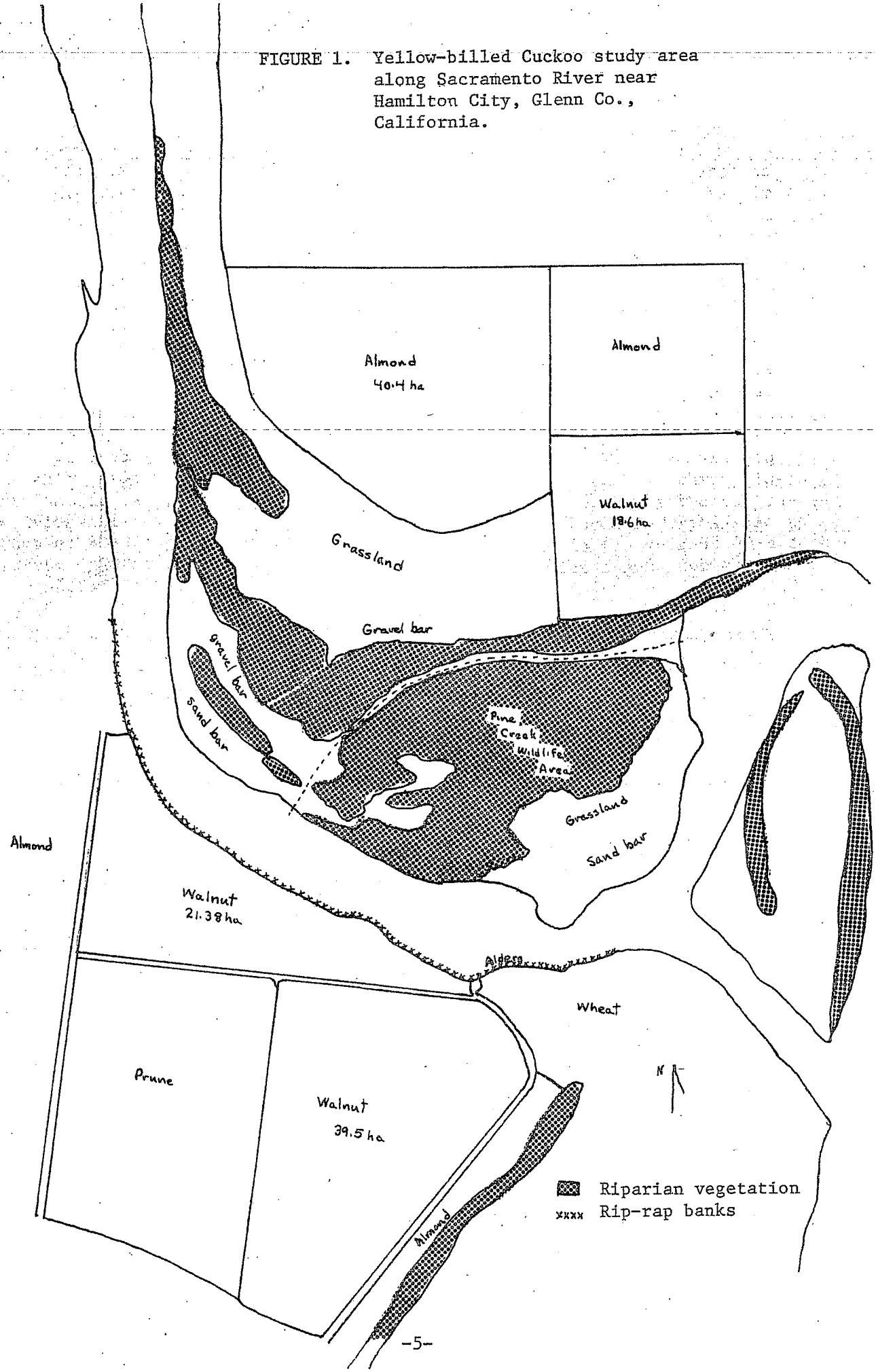
The riparian area was Fremont Cottonwood (Populus fremontii)-willow (Salix spp.) woodland. The western three-quarters of the area was quite uneven, cut by many channels running east and west which were formed over the past 120 years as this land was being deposited as the river meandered south. The canopy over this area was 95% cottonwood rising to 20-30 m. The remainder of the canopy was willow. The upland parts of this area had a ground cover of mugwort (Artemesia douglasiana) and little understory. There was little blackberry (Rubus spp.) in the entire site. The channels were either open areas or densely lined with willow, box elder (Acer negundo) and white alder (Alnus rhombifolea) depending on the water availability and soil texture. One main channel cut through the middle of the area and numerous ponds were formed along it. This channel was surrounded by dense stands of overhanging willow and box elder with cottonwood canopy. Much of the area was strewn with driftwood from winter floods.

The eastern quarter of the riparian area was made up of dense willow thickets reaching 8 m. There was a large beaver pond in this area with marsh vegetation surrounded by willows. There was little or no ground cover in this area.

The walnut orchard to the north was approximately 18.6 ha. The trees have been planted within the last 8 years. They reached a height of only 4 m and provide 10-20% canopy cover. The almond orchard of 40.4 ha was more mature with the trees reaching 5-6 m and forming a 30-40% canopy cover.

The 21.4 ha walnut orchard closest to the river on the southwest side was surrounded on the north by a rip-rap bank and on the south and west by a levee road. The trees were about 15-20 years old and reach a height of 7-10 m. They formed a closed canopy in most places with a canopy cover of 90%. In a few low places open areas occurred where trees had died from oak root fungus. The back walnut orchard of 39.5 ha was similar but toward the south end the trees were stunted and the canopy cover was nearer 50%. The ground was kept free of vegetation by mechanical choppers, scraping and discing. Herbicides were used along the levees and at the base of the trees. The almond orchard to the west was also mature with the trees reaching 7 m and forming a canopy cover of 50%. To the east of the front orchard the rip-rap was lined with white alders.

FIGURE 1. Yellow-billed Cuckoo study area along Sacramento River near Hamilton City, Glenn Co., California.



RESULTS

Foraging: Method and Area Used

Cuckoos foraged by flying to a perch in a tree and waiting for insects to reveal themselves by movement. The time spent on each perch varied from 5 seconds to 10 minutes. During shorter time periods the search was active but when they sat for long periods of time they were quite passive. In addition to this principal feeding technique, four other methods were observed on rare occasion: they hopped around on the ground under the walnut trees and caught grasshoppers; sat on the nest and snapped up small flies; attempted to catch flying insects like a flycatcher; and flew through the trees and brushed the leaves with their wings in an attempt to flush prey. This last method has not been reported in the literature. Cuckoos normally slip through the trees without moving a leaf. This behavior was evidently intentional and was a departure from the norm.

Table 1 summarizes foraging behavior observed. It shows a marked preference for foliage below 3 m and for white alders for foraging. This may not be an actual preference, but an artifact of the ease of viewing the cuckoos in these locations. I found it impossible to follow their movements through willow thickets and in the tops of 30 m cottonwood trees. A better estimate of foraging preference comes from examining Table 2 which shows the origin of 138 food items: 55% from riparian, 33% from alder rip-rap banks and 12% from orchard.

At times I saw the cuckoos fly to the tops of the cottonwoods in Pine Creek Wildlife Area, then an hour later fly back across the river to the alders below the walnut orchard on the rip-rap bank, catch several grasshoppers for the young, catch and eat several more grasshoppers, and then return to the tops of the cottonwoods across the river. This suggests that the grasshoppers were not preferred prey, but being abundant, were gathered when the preferred caterpillars and katydids could not be located within a certain time period.

Figure 2 shows foraging areas of the four pairs for which nests were located. Four other pairs were believed to be foraging and nesting in this area and an additional two unmated males also used the area. If their territories were also projected on the map, considerable overlap of foraging area would have occurred. Table 3 describes the size and habitat type of each area. Sizes were estimated using flight paths from nest to foraging area and back. In most cases it was impossible to tell how far the cuckoos were moving back into the riparian after they reached the cottonwoods. The area estimate for pair #1 is the most accurate and for pair #3 the most subjective. The foraging areas ranged from 10.8 - 28.3 ha, in comparison to 10 ha estimated by Gaines (1974). When water and open areas are removed, the areas ranged from 8.8 - 10.8 ha and averaged 10.1 ha. This 10.1 ha area was made up of various combinations of orchard and riparian woodland.

Prey: Potential and Actual

Potential prey was discussed in an interview with an entomologist, Dr. Donald Chandler. It was his feeling that little prey would be available in maintained walnut or almond orchards. He considered members of the order Orthoptera the most likely prey, with grasshoppers found on or near the

FIGURE 2. Yellow-billed Cuckoo foraging areas.

ground and katydids found in the upper foliage. Dragonflies (Odonata) were also considered as likely prey in orchards but were considered very difficult to catch. Wood boring insects were considered unlikely due to pruning, and any insect that caused defoliation, such as a caterpillar, would be sprayed if it became common. Tent caterpillars (Lasiocampidae) were considered an exception due to the spotty nature of their occurrence.

Table 4 summarizes Dr. Chandler's feelings on potential prey in riparian woodland. He believed that caterpillars would prove to be the most dependable arboreal food source.

The actual prey used is listed in Table 1 and the origin of the food items is shown in Table 5. Ground and shrub dwelling brown grasshoppers formed a major part of the diet at nest #1 (37%) but were rarely used by the other three pairs (5%). The alders in which the grasshoppers were gathered were close by the first nest and the prey was abundant, providing an opportunity unavailable to the other three pairs. The percentage of katydids in the diet rose dramatically as the summer progressed. The first pair used 7%, the second and third pairs used 40% and the fourth pair 70%.

As Chandler predicted, little food was obtained in the orchard and of the major food items only katydids were gathered there in significant numbers (20%). Grasshoppers obtained in the orchard were caught on the ground and in low branches.

The sphinx moth larvae were never encountered in the field, so their exact origin is unknown. The cuckoos usually returned from the tops of the cottonwoods with this prey.

The use of tent caterpillars as a major food source has been mentioned in many publications. Even though tent caterpillars were common in both the walnut orchard and riparian areas, I saw cuckoos inspecting the webs only once and only one caterpillar that appeared to be of this type was brought to the nest.

Nest Site Selection

I found four nests in the study area. Three were in a walnut orchard and the fourth was in the riparian area (Figure 2). Table 6 analyzes the nesting sites.

The nests were made primarily of willow twigs. Nest #1 contained many star thistle branchlets, which were available close to the nest site. The willow twigs must have been brought from across the river, since no willows were near the nest. Prior to the discovery of nest #1, a cuckoo was seen gathering twigs on the riparian side of the river several times and on June 15 one was seen flying across the river with two twigs and a cottonwood leaf.

Nesting Behavior and Success

Nest #1 was the only one at which it was practical to set up a blind and observe nesting behavior. This nest was found on June 15, or 4 days after the first egg was laid (see Table 7 for nest timing). Whenever

the nest was checked prior to the hatching of the first young on June 22, an adult was incubating. After the first young hatched an adult continued to incubate constantly until June 27 when the third young hatched. At this time incubation (or brooding) was abandoned.

The two adults were identifiable by the second day of observation, one having a heavier, darker bill and several minor behavioral and plumage differences. The work load was shared equally, with cuckoo A bringing slightly more food items and at a faster rate than cuckoo B (Table 8). Both brought in a similar proportion of the food types, indicating similar foraging practices.

The adults came to the nest with food at an average rate of once every 31 minutes. With one young in the nest they fed 1.4 times/hour, with two young 1.9 times/hour and for the one day with three young 3.4 times/hour. Table 8 also summarizes the feedings for each young each day. Figure 3 illustrates the number of food items brought to each young per hour. It also shows the fluctuation in food needs of the young. The young needed small amounts of food for the first three days, their food requirements were very high for days 4-6 and then dropped off on day 7. This corresponds to their physical development. On the seventh day, they pulled and ate the sheaths of their feather quills and became fully feathered in a few hours. Their development then slowed greatly as did their need for food, as indicated by their much less active begging from day 7 on.

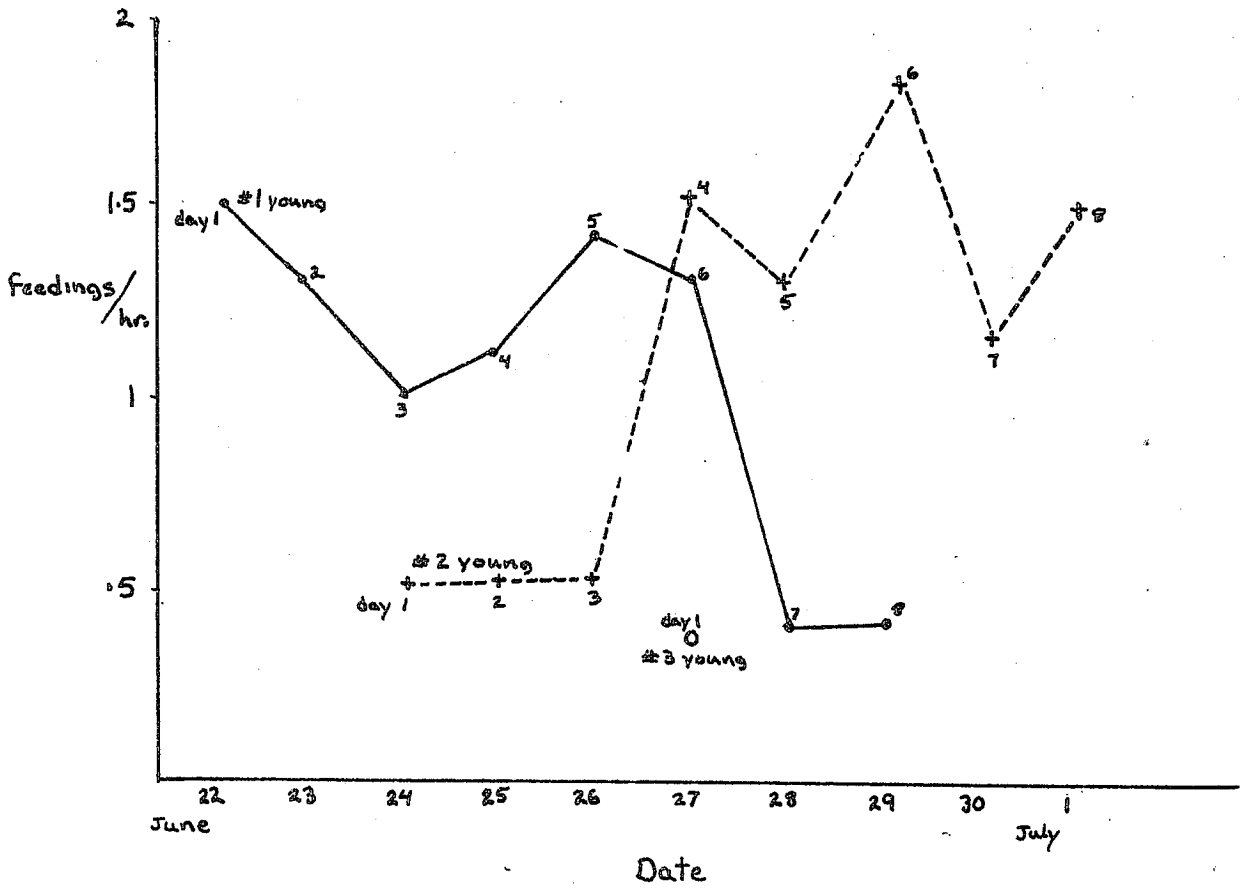
In nest #1, the third young hatched on a day when both siblings were in the high food demand stage. The parents tried to feed all three young for 6 hours but got very few food items to young #3. At the end of this period, unable to satiate this young's hunger, one adult picked up the vigorously begging young in its bill and flew off toward the river. The adult returned a few minutes later without it. Preble (1957) also comments on this behavior, so it is not an isolated instance.

The fact that cuckoo eggs hatch asynchronously has long been known. Incubation starts when the first egg is laid, so young of different ages are in the nest. The four nests observed had an average of 2.2 days and a range of 1 to 4 days between eggs hatched. Table 7 illustrates this timing and also shows the wide spread of egg laying from June 12 to August 2.

Nesting success, defined as the percent of nests fledging young, was 100%. This is an extremely high rate compared to 49% for the average open cup nest of temperate zone birds with altricial young (Skutch 1976). Egg success of 57%, defined as the percent of young fledged from eggs laid, was also higher than the average of 45.9% reported by Skutch (1976). The figure of 64% of eggs hatched compares well to 60% listed by Welty (1962) for a variety of open cup nesting species. Nesting success is summarized in Table 9. The figures for the cuckoos are based on a sample of only four nests, far too few to draw positive conclusions.

Nest #1 had the lowest success rate with only one young out of five eggs surviving. The five eggs was the highest total for any of the nests. It is possible that these eggs were laid by two females since a third cuckoo came to the nest several times and fed the young. A

FIGURE 3. Division of food brought to Yellow-billed Cuckoo young at nest #1



fourth cuckoo also visited the nest but never attempted to feed. Only three eggs hatched and the other two eggs disappeared before they could be removed. Number 3 young was removed from the nest by the parents and #2 young was not seen after the third day it was out of the nest. Number 1 young was still being fed near the nest at least 18 days after fledging.

Pesticides

Pesticides can affect birds in various ways. The most obvious of these are direct poisoning of the sprayed adult, nestling or egg and death by ingestion of poisoned insects. These effects have been well documented. Organophosphate pesticides parathion and phosphamidon, and the chlorinated hydrocarbon pesticides heptachlor and chlordane have been shown to be very toxic to birds (Calif. Dept. of Food & Agriculture 1978). There is nothing in the literature specifically about cuckoos in this regard.

Behavioral changes are much harder to determine, but have been documented in several studies. Finley (1965) noted a marked change in grouse behavior after spraying mountain forests with phosphamidon. Change in foraging behavior has been observed in other studies (Ferguson 1964).

The accumulation of chlorinated hydrocarbon residues in species high in the food chain, resulting in reproductive disruption, is well known. Little work has been done on small birds in the middle of the food chain. Grocki and Johnston (1974) and Johnston (1975) have studied this factor. They found that migrant Yellow-billed Cuckoos in Florida contained 0.42 ppm DDT in spring, and 1.12 ppm DDT in fall, based on lipid weight and a total sample of 17 individuals. This concentration compares to 5 - 25 ppm (fresh weight) for various other insectivorous birds. If figured on a lipid weight basis, these concentrations would be much higher. They concluded that the cuckoos have a very low pesticide burden, possibly resulting from their specific diet or their high arboreal feeding position. From this study there seems to be little reason to suspect pesticide residues to be an important factor in the decline of the cuckoos. However, caution must be used in drawing positive conclusions for the California population based on data from the eastern United States.

The effects of pesticides on insect food supply of bird populations has been poorly studied, but it has been commented on by many authors as an area that needs study. The best documentation is found in Stewart et al. (1946), Hotchkiss et al. (1946), Pimental (1971), Hanson (1952), Ferguson (1964), Finley (1965) and Rudd and Genelly (1956). I found no studies in the literature of pesticide effects on cuckoo's food supply.

With the exception of tent caterpillars and grasshoppers, both considered only minor pests, I could find no overlap between orchard pests and Yellow-billed Cuckoo food. Any effect on cuckoos from food limitation must come from effects on non-target insects. Table 10 shows the major crop pests in walnut and almond orchards, what controls are used and spray timing. In almonds the only potential direct problem would come from spraying for second brood navel orange worms in mid-July. For this spraying Guthion (an organophosphate) and Sevin (a carbamate compound) are usually used. Neither are known to be highly toxic to birds. In

walnuts the dangers are greater, with a codling moth (second brood) - aphid spraying during the last two weeks in June and a walnut husk fly spraying in early to mid-August. The relatively non-toxic (to birds) Guthion, Sevin and Zolone (an organo phosphate) are used for the codling moth - aphid spraying and the highly toxic (to birds) phosphamidon, parathion and malathion (all organophosphates) are used for the walnut husk fly spraying. Both of these sprayings occur during the cuckoo's nesting season.

In the walnut orchard only one application of pesticides was made between June 15 and August 25. This was a treatment for codling moths and aphids with Zolone on June 28. At this time there were two young, aged 5 and 7 days, in nest #1. Neither of the other orchard nests yet contained eggs. Young #1 fledged the day after the spraying and fell to the ground soon after fledging. Young #2 fledged two days later and also fell to the ground. The young hopped around on the orchard floor for several days, hiding in grass clumps, along the back of the orchard and on the walnut tree trunks up to the English walnut graft. Number 2 young was last seen on July 3 at 10 days of age in a clump of grass at the back of the orchard. This area was sprayed with the herbicide 2,4,5-T the next day. Number 1 young returned to the trees on July 4 or 5 at the age of 13 - 14 days. The young in the remaining three nests did not fall to the ground upon fledging, but stayed in the trees near the nest site. It is likely that pesticide exposure effected the balance of the young in nest #1.

The only noticed effect on food supply from the spraying was the death of tent caterpillars whose webs were below 6 m. Since this insect was such a seldom used food source the effect on nesting seems minimal.

Two unhatched eggs were removed from nest #2 and one from nest #3 after incubation was abandoned. These eggs were analyzed at the Department of Fish and Game pesticide laboratory. The eggs from nest #2 contained 0.08 ppm DDE and the egg from nest #3 contained 0.11 ppm DDE. Both figures are quite low and indicate that persistent pesticide buildup is not a major problem in cuckoo reproduction.

Surveys in Study Area

I conducted surveys using tape recorded cuckoo calls on August 9 in the walnut orchard and on August 10 in the riparian area. The location of each sighting is plotted on Figures 4 and 5. The results were 7 adults, 4 immatures and 2 additional unmated adult males on the orchard side and 7 adults, 3 immatures and one unmated male on the riparian side. Taking into consideration duplicate counts of two birds, 13 adults, 7 immatures, and 2 unmated males were found. This is a very high percentage of the total of 16 adults (8 pairs), 11 immatures and 2 unmated males which I believed, based on daily movements, differences in call, etc., to be present in the study area. The unmated males were determined by the constant use of the cooing call, which is believed to be used to attract a mate. The survey was conducted again in the orchard August 24 and only 2 adults were found, indicating that southward migration was already underway or that they had become unresponsive due to post breeding molt.

FIGURE 4. Orchard area census, August 9, 1979

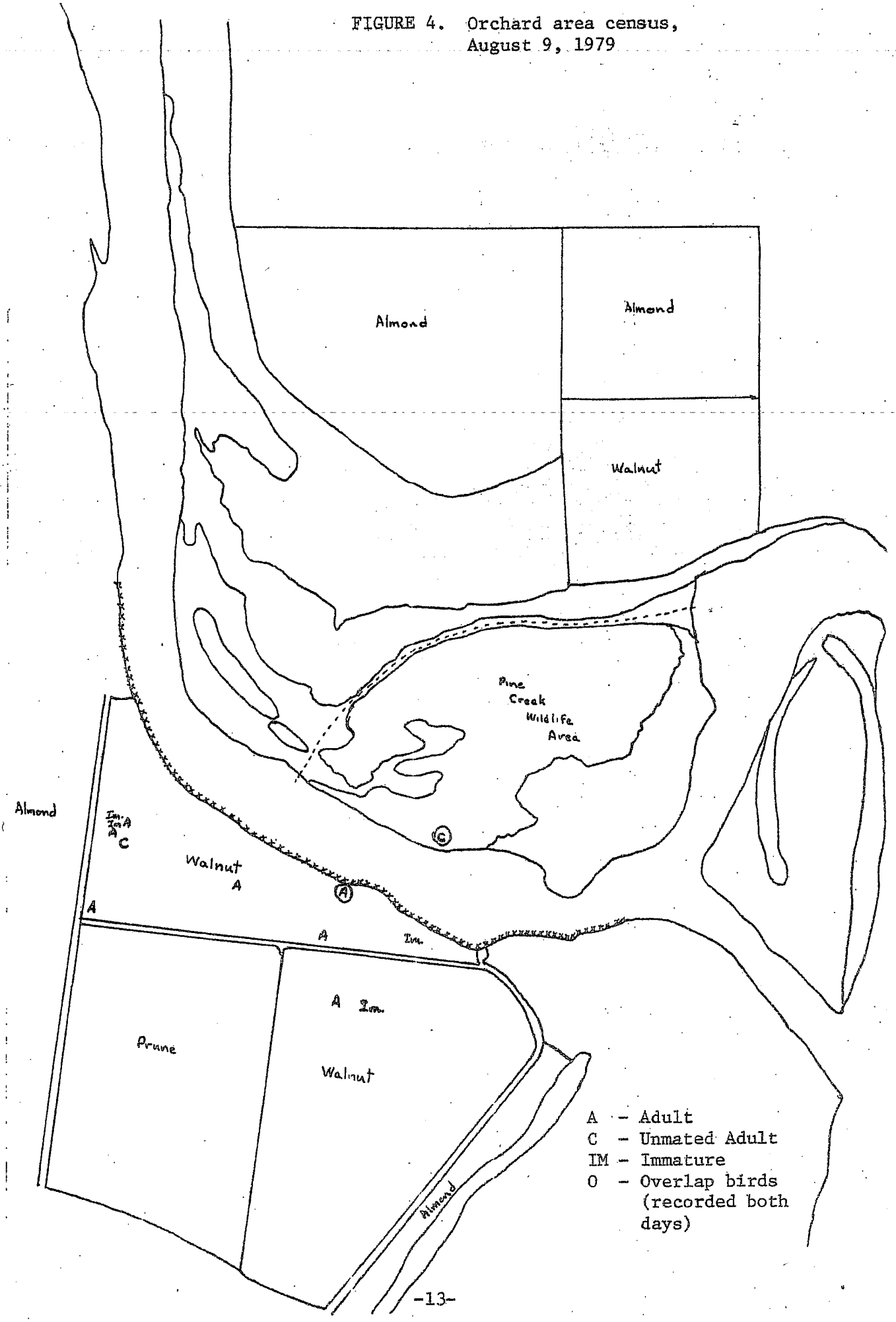


FIGURE 5. Riparian area census,
August 10, 1979

The survey total of 22 cuckoos in two days is unprecedented in the Sacramento Valley and approaches 50% of the entire number recorded in the valley on the 1973 and 1977 censuses.

Surveys Away From the Study Site

I conducted surveys on August 3 and 4 in potential nesting habitat at Clear Lake, Lake County. Suitable habitat appeared to be present at Rodman Slough on the northwest side of the lake and at spots along the southwest shore between Clear Lake State Park and Lakeport. No cuckoos were found at these locations.

Additional observations of cuckoos during summer 1979 were:

1 - Sacramento River 1.6 km above Bow River Marina	July 1
1 - Kopta Slough, Woodson Bridge State Recreation Area	July 14
1 - Indian Fisheries Slough, Bidwell River Park	July 28
1 - Red Bluff Diversion Dam	July 29

The July 29 record for the Red Bluff Diversion Dam is the northernmost in the Sacramento Valley since 1930. This location is about 16 km north of Todd Island, the northern limit of their known range in recent years.

(DISCUSSION begins on page 27.)

TABLE 1

Foraging Observed

Date	Height (m)	Species of Tree	Method	Duration of Observation (minutes)	Success Observed
June 12	25	Cottonwood	Flycatching	1+	No
June 14	6	Willow	Search	2	No
June 14	15	Cottonwood	Dive	1+	2.5 cm beetle
June 19	2	Willow	Search	1+	3 cm caterpillar
June 19	15	Cottonwood	Search	3	No
June 22	20	Cottonwood	Search	3	No
June 25	3+	Alder	Search	4	No
June 26	3+	Alder	Search	3	No
June 26	25	Cottonwood	Search	1	No
June 27	3+	Alder	Search	1	No
June 27	3	English walnut	Snapped bill	10	2 small flies
June 28	3+	Alder	Search	3	No
June 28	3	English walnut	Snapped bill	1	small fly

TABLE 1 (continued)

Date	Height (m)	Species of Tree	Method	Duration of Observation (minutes)	Success Observed
June 29	3+	Alder	Search	5	No
June 29	2	English walnut	Dive	0.5	3 cm caterpillar
July 2	3+	Alder	Search	15	No
July 2	Ground	Orchard	Hop&snap	1	4 cm grasshopper
July 2	4+	English walnut	Search	6	No
July 2	Ground	Orchard	Dive	1	Misses
July 8	3+	Alder	Search	6	3 grasshoppers (4 cm)
July 9	3+	Alder	Search	4	No
July 9	2	Elderberry	Search	2	No
July 10	3+	Alder	Search	40	9 grasshoppers
July 10	Ground	Orchard	Hop&snap	1	grasshopper
July 12	3+	Alder	Search	5	No

TABLE 1 (continued)

Date	Height (m)	Species of Tree	Method	Duration of Observation (minutes)	Success Observed
July 13	3+	Alder	Search	7	No
Aug. 11	20	Valley oak	Dive	10	5 cm katydid
Aug. 13	3+	Willow	Hop&snap	0.5	5 cm katydid
Aug. 14	20	Cottonwood	Dive	1	6.5 cm katydid
Aug. 14	30	Cottonwood	Search	2	No
Aug. 16	3	Willow	Hover&snap	1	4 cm katydid
Aug. 17	20	Cottonwood	Dive	3	2.5 cm katydid
Aug. 17	3-10	Cottonwood	Search	5	Misses
Aug. 17	3	Willow	Hover	1	Misses
Aug. 17	3	Willow	Hop&snap	2	Praying mantis
Aug. 18	20	Cottonwood	Search	10	No
Aug. 18	30	Cottonwood	Search	5	No

TABLE 2
Observed Food Items

	Nest #1	Nest #2	Nest #3	Nest #4	Total	Percent
Beetle (Coleoptera)	5	-	-	-	5	1.8
Sphinx moth larvae (Sphingidae spp.)	61	6	5	8	80	28.6
Small green caterpillar (Lepidoptera spp.)	15	-	-	-	15	5.4
Dark caterpillar (Lepidoptera spp.)	5	-	-	-	5	1.8
(Total caterpillars (Lepidoptera)	81	6	5	8	100	35.7)
Brown grasshopper (Acrididae spp.)	81	-	2	1	84	30.0
Green grasshopper (Acrididae spp.)	8	-	1	-	9	3.2
Katydid (Tettigoniidae)	16	1	9	23	49	17.5
(Total grasshoppers (Orthoptera)	105	1	12	24	142	50.7)
Praying mantis (Manteodea)	-	-	1	1	2	.7
Damselfly (Zygoptera spp.)	2	-	-	-	2	.7
Dragonfly (Anisoptera spp.)	4	-	-	-	4	1.4
Cicada (Cicadidae)	2	-	-	-	2	.7
Lacewing (Neuroptera)	1	-	-	-	1	.4
Mosquito hawk (Tipulidae spp.)	1	-	-	-	1	.4
Fly (Diptera)	2	-	-	-	2	.7
Unidentified	11	-	-	-	11	3.9
Regurgitated	8	-	-	-	8	2.9
Total	222	7	18	33	280	

TABLE 3

Size and Habitat Type of Foraging Areas
Used By Yellow-billed Cuckoos

Habitat Type	Pair #1 (ha)	Pair #2 (ha)	Pair #3 (ha)	Pair #4 (ha)
Riparian	5.1	6.1	3.1	9.9
Walnut orchard	3.7	4.7	3.0	-
Almond orchard	-	-	4.7	-
(Total wooded	8.8	10.8	10.8	9.9)
Open	5.6 (20%)	1.9	6.0	-
Water	13.9 (49%)	3.9	6.3	0.9
Total	28.3	16.5	23.0	10.8

TABLE 4

Potential Prey In Riparian Woodland (Donald Chandler pers. comm.)

Insect Types	Comments
ORTHOPTERA	Often found in large numbers.
Grasshoppers (Acrididae)	Found on or near the ground except for a few arboreal species.
Katydids (Tettigoniidae)	Found high in trees. Often fairly common.
Praying mantids (Manteoda)	Never in large numbers.
HEMIPTERA	Ones that are large enough are distasteful, even poison.
HEMOPTERA	
Cicadas (Cicadidae)	Cylic in nature. Some years abundant, other years not found at all.
ODONATA	
Dragonfly (Anisoptera)	Very difficult to catch. Can be very abundant.
LEPIDOPTERA	
Moths (larvae) (Heterocera)	Many arboreal species. A much more likely food source than butterfly larvae. Can be very common.
Butterfly (larvae) (Rhopalocera)	
COLEOPTERA	
Wood boring beetles (Tetramera)	All dusk flying, hide under bark or in cracks on shady side of tree. Will only move in daytime if sun hits them. Little chance for cuckoos to catch them.

TABLE 5

Source of Food Items

	Orchard		Riparian		Alders		Total
	No.	Percent	No.	Percent	No.	Percent	
Sphinx moth larvae	-	-	36	95	2	5	38
Small green caterpillar	1	12	7	88	-	-	8
Dark caterpillar	-	-	2	100	-	-	2
Brown grasshopper	7	15	2	4	39	81	48
Green grasshopper	-	-	3	75	1	25	4
Katydid	6	20	23	77	1	3	30
Beetle (small)	-	-	2	67	1	33	3
Dragonfly	1	100	-	-	-	-	1
Fly	2	100	-	-	-	-	2
Praying mantis	-	-	1	100	-	-	1
Total	17	12%	76	56%	44	32%	137

TABLE 6
Nest Site Analysis

	Nest #1	Nest #2	Nest #3	Nest #4
Location	Walnut orchard	Walnut orchard	Walnut orchard	Riparian woodland
Type of tree	English walnut	English walnut	English walnut	Sand bar willow (Salix)
Height from ground (m)	4.0	3.0	4.3	2.5
Horizontal branch?	Yes	Yes	Yes	Yes
Distance from trunk (m)	4.0	4.5	4.0	-
Distance from end of branch (m)	0.3	0.5	1.0	0.3
Shrub layer	None	None	None	Willow
Ground cover	Bare	Bare	Bare	Water
%foliage cover in area	80%	85%	85%	70%
%foliage cover above nest	95%	98%	95%	80%
Distance of nest to foliage above (cm)	15	25	90	30
Distance to edge of woodland (orchard) (m)	12.5	46	33	0
Distance to water (m)	25	150	58	0
Distance to nearest riparian vegetation (m)	283	300	267	0

TABLE 7

Nest Timing

	Nest #1	Nest #2	Nest #3	Nest #4
Egg laying date	6/12, 6/14, 6/17	7/05	7/12, 7/13	7/28, 7/29, 8/02
Hatching dates	6/22, 6/24, 6/27	7/15	7/22, 7/23	8/07, 8/08, 8/12
Fledging dates	6/29, 7/01	7/22	7/29, 7/30	8/14, 8/15, 8/19

TABLE 8

Feeding Schedule at Nest #1

Date	No. of Young	Feedings	Feedings/ Hour	Time Between Feedings		Young Receiving Food		
				Mean	Range	No.1	No.2	No.3
June 22	1	12	1.5	39.4	4- 61	11	-	-
June 23	1	11	1.[illegible]	43.6	8-106	9	-	-
June 24	2	22	1.7	31.5	6-105	13	7	-
June 25	2	13	1.6	34.9	4- 77	9	4	-
June 26	2	19	1.9	30.5	1- 70	14	5	-
June 27	3	27	3.4	16.2	2- 73	10	12	3
June 28	2	16	1.7	35.9	5- 87	4	12	-
June 29	2	17	2.4	25.8	4-101	3	13	-
June 30	1	11	1.3	40.5	2- 98	-	10	-
July 1	1	8	1.5	31.6	7- 90	-	8	-

(Continued next page)

TABLE 8 (Continued)

Feeding Schedule at Nest #1

Date	Adult Feeding			Type of Food								Time Between Feedings			
				Caterpillar		Grasshopper		Katydid		Misc.		Adult A		Adult B	
	A	B	C	A	B	A	B	A	B	A	B	Mean	S.D.	Mean	S.D.
June 22															
June 23															
June 24	1	1		1	1										
June 25	4	7	1	4	5							95	23.8	90	16.1
June 26	7	11	1	6	5	1	4		1		1	70	41.9	52	37.7
June 27	16	10		2	4	7	2	1	-	4	3	27	42.4	35	20.8
June 28	8	6		2	3	4	1	1	-	2	-	34	16.3	79	22.6
June 29	7	7		3	3	2	3	1	-	1	1	14	7.8	45	45.4
June 30	5	2		3	1	1	1	-	1	1	-	39	47.4	67	-
July 1	4	2	_	2	-	2	2	-	-	-	-	22	25.4	10	-
Total	52	46	2	23	17	17	13	3	2	8	5				

TABLE 9

Nesting Success

	Eggs	Eggs Hatched	Young Fledged	Young Survived (1 Week)
Nest #1	5	3	2	1
Nest #2	3	1	1	1
Nest #3	3	2	2	2
Nest #4	3	3	3	2-3
Total	14	9 64%	8 57%	6-7 43-50%

3.5 eggs/nest
1.5-1.75 young/nest
Nesting success 100%
Egg success 57%

TABLE 10

Potential Pesticide Exposure

Crop	Major Pests	Spray Dates	Pesticide Used
Walnuts	Walnut husk fly	Early - mid-Aug.	Phosphamidon, Ethion, Trithion, Malathion, Parathion
	Codling moth (second brood)	Last 2 weeks June (1st brood April)	Sevin, Zolone, Guthion
	Aphid	April - Aug. as needed	Phosphamidon, Zolone Thiodan
	Mites	May - June	Omite, Zolone, Ethion, Trithion, Kelthane, Chlorobenzilate, Tedion
	Navel orange worm	Control with spray for codling moths	
	Scale	Winter	Dormant oil spray and pesticides
Almonds	Navel orange worm	April or mid-July	Guthion, Sevin
	Peach tree borer	Winter	Dormant oil spray
	Scale	Winter	Dormant oil spray

DISCUSSION

All evidence points toward this species' population being limited by food. Nolan and Thompson (1975) studied nesting birds in Indiana for 13 years from 1959 to 1973. They found that in years of periodic cicada outbreaks cuckoos timed their nesting to the outbreaks rather than to the emergence of annual cicadas, around which their nesting was usually timed. They also laid significantly more eggs per nest and even practiced nest parasitism in the years of periodic cicada outbreaks. The latter practice was not found in years of normal food supply.

Asynchronous hatching is also associated with unusual difficulties in obtaining enough food for the young. Cuckoos practice this type of hatching strategy, and the present study shows that this practice spaces the young so all will not be at peak food demand at the same time. This method of hatching allows the runts of the brood to starve in times of limited food supply, adjusting the effective clutch size to available food resources and avoiding starvation of the entire brood.

The cuckoos on the study area spaced out reproduction throughout the summer. In fact there was no overlap in egg dates between any of the four nests. This is another method to share a scarce resource, i.e., food. It is possible that cuckoos use this time spacing method instead of territory. I have found no evidence of territoriality in this species. Being non-territorial would allow cuckoos from different nests to share in a localized short term abundance of food.

The removal of young #3 from nest #1 when its food needs could not be met is also good evidence of a food stress related action. The cuckoos' entire breeding cycle is geared to taking advantage of a short term abundance of food. This holds true for everything from food induced laying, short incubation period and rapid development of the young.

To know that cuckoos are limited by food does not answer the question of why they are less common than the available habitat would predict they would be. One possible answer has to do with preferred food items. They seem to prefer very large, green prey items; katydids and sphinx moth larvae. These items are not abundant and require a great deal of time to find. They would be especially hard to find on windy days. This year was an especially good year for grasshoppers, a non-preferred food source, and may have been a better than average year for katydids. It is quite possible that this was not an average year in regards to food and that fledging success was higher than normal due to unusually high levels of food. A one-summer study cannot answer that question.

The orchard nesting of three of the four pairs also raises questions about the abundance of the species. They obviously find the orchard an acceptable or even preferred place to nest. They have long been known to need horizontal branches 2 - 5 m above the ground and this study bares that out. This type of branch is missing in many riparian associations. Cottonwoods don't provide the needed canopy cover and the branches are not low enough or horizontal enough to be used for nesting. The necessary conditions would be met mainly in willows growing out over a slough (as in nest #4) and in box elders and white alders growing near a slough or an opening. Interiors of willow or box elder thickets are generally not suitable for nesting. Necessary nest site conditions would usually be met at the edges.

The riparian part of the study area had few sites where nesting was possible: along the major slough, near the two ponds, along the north edge bordering the walnut orchard and in a few scattered spots toward the southeast. It is possible that a lack of nesting sites forced the cuckoos across the river into the orchard, but still they had to return to the riparian area for food and nesting materials. The early to mid successional stages of riparian forest favor the cuckoos for nesting, even though the mature vegetation is used for foraging. A non-changing river with only mature cottonwood or valley oaks, rip-rapped banks and no new vegetation growing up would not be favorable.

Nesting in orchards also leads to questions of pesticide exposure. This behavior would be the main reason for pesticide exposure. No spraying is conducted in the riparian woodland, though drift from aerial spraying may at times reach these areas. On several occasions, pesticide drift was noticed reaching riparian areas when aerial spraying was done on nearby orchards and fields. The unfledged young, fledged young and incubating adults would be affected the most. The more toxic pesticides used in August for walnut husk fly are fortunately used after the height of nesting, but undoubtedly dependent young are still present in the orchards at this time. The limiting of food supply by spraying the orchards appears less important than the possible behavioral alteration (such as loss of balance) or even death caused by contact with the pesticides. However, any reduction in food supply may have an effect on such a food related species. Roger Wilbur (pers. comm.) relates that prior to extensive use of pesticides, cuckoos were commonly observed foraging in peach and prune orchards near Yuba City. It is very likely that pesticides have had a direct effect in limiting numbers of cuckoos nesting and foraging in orchards.

Cuckoo habitat seems to be much wider than that defined by Gaines (1974). They were found in areas other than riparian for nesting. They foraged extensively on rip-rap banks with a few scattered white alders and were found many times in areas which did not have a dense understory (including all nesting sites). Many of the recommendations of this paper deal with maintaining necessary habitat.

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