

BREEDING STATUS OF THE TRICOLORED BLACKBIRD, 1969-1972¹

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During 1969-1972, 164 breeding colonies of tricolored blackbirds were found in California and southern Oregon. The location of the colonies, their sizes (including acreage, number of birds, and number of nests), and nesting habitats are given and comparisons made with previously reported data. The tricolor's general range and major breeding areas have remained unchanged during the past 35 years, but in the Central Valley, population size has declined, perhaps by more than 50%. Possible causes for the decline are given, and other aspects of the tricolor's breeding ecology are discussed.

INTRODUCTION

Since 1967 we have studied blackbird damage to rice in California. Our first step in defining this problem was to investigate the population status of the various species involved in depredations, with particular emphasis on the tricolored blackbird (*Agelaius tricolor*) because of its endemic distribution. Neff's (1937; 1942) studies provide the basis for much current knowledge about the tricolor, but because his data were gathered more than 30 years ago and because more recent workers (Orians 1961a, 1961b; Orians and Collier 1963; Payne 1965; and Collier 1968) have not provided data on the tricolor's general distribution and numbers, its present status was uncertain. We therefore studied the tricolor during four breeding seasons during 1969-1972. This paper presents our findings on the size and distribution of the tricolor breeding population, and compares them with earlier findings.

METHODS

Each spring (April-June) different portions of the tricolor's range were surveyed by auto for breeding colonies. In 1969 and 1970, the survey was concentrated in the Central Valley (combined Sacramento Valley: Tehama, Butte, Glenn, Colusa, Sutter, Yuba, Yolo, Solano, and Sacramento counties; and San Joaquin Valley: NW Kern, Kings, Tulare, Fresno, Madera, Merced, Stanislaus, and San Joaquin counties). In 1971 we attempted to survey the entire breeding range (excluding Baja California) by driving more than 8,000 miles and visiting most of the reported breeding areas (Table 1) from San Diego through southern Oregon. In 1972 our search was conducted from the northern San Joaquin Valley through southern Oregon. Some of the tabular data also include four colonies we found during brief explorations in

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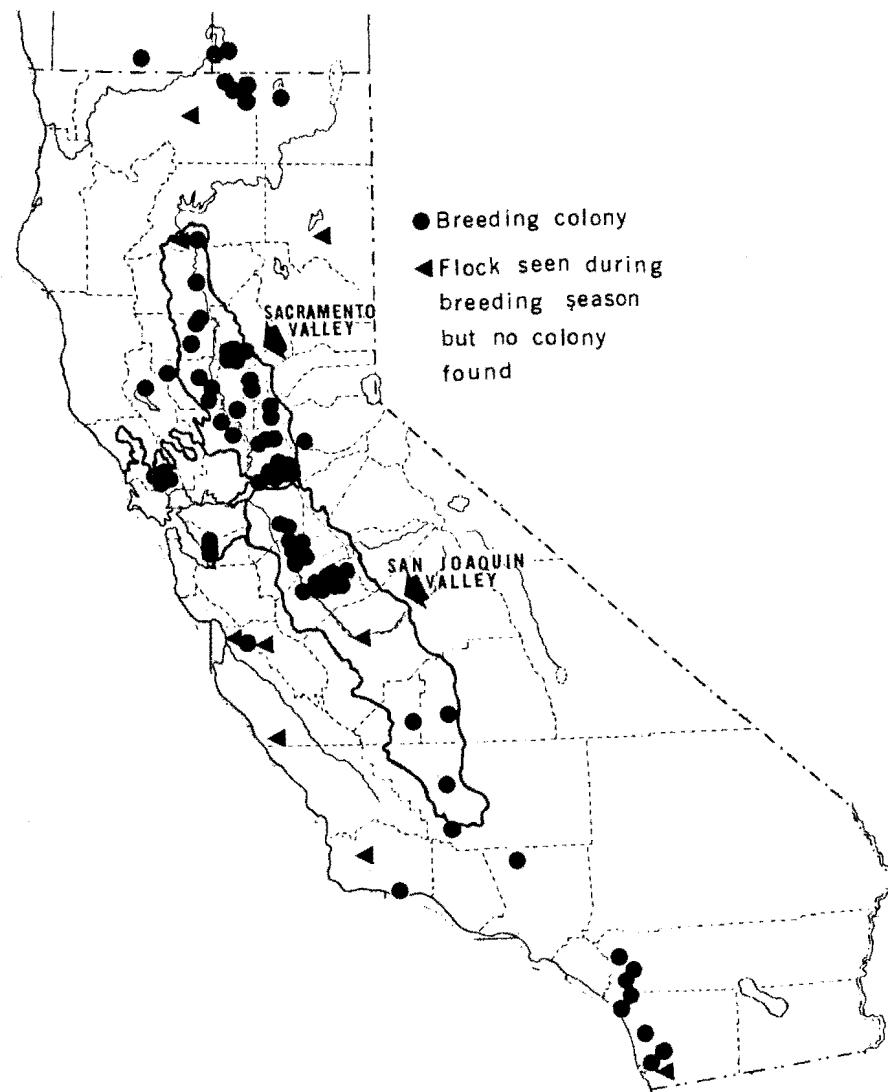


FIGURE 1. Location of tricolored blackbird breeding colonies 1968-1972. (Some of the locations represent more than one colony.)

the Sacramento Valley in 1968. During each of the survey years, records of several additional colonies were provided by amateur and professional ornithologists. However, because we could not thoroughly investigate all colonies and because many of our cooperators' reports were incomplete, all data are not available for each colony.

Estimates of different population segments were made by counts and by projections based on the findings of Payne (1965), Lack and Emlen (1939), and Lack (1968) who indicated that each tricolor female attends only one active nest and that the male:female ratio averages about 1:2. If a colony was located early in the nesting cycle when both males and females were present, the breeding population was directly estimated by counts, and the number of active nests to be built was projected. During later nesting stages, such as incubation when the males are absent, or the nestling stage when both sexes may be away from the colony in search of food, the nests were counted and the breeding population was projected.

DISTRIBUTION OF COLONIES

Geographic

Including the four colonies in 1968, we found 168 breeding colonies at 113 locations, each at least 1.6 km (1 mile) apart (Table 1; Figure 1). About 78% (131) of the colonies were in the Central Valley, with 48% (80) in Sacramento Valley, and 30% (51) in the San Joaquin Valley. The remaining 22% (37) were in other parts of California and in southern Oregon. The counties (all in the Central Valley) where the most colonies were found in a single season were Sacramento (11), Merced (10), Stanislaus (7), Glenn (7), and Colusa (4).

Neff (1933; 1937) reported tricolor colonies in 26 counties in California and one county in Oregon; but he believed occasional breeding was likely in at least 15 additional counties. Later, breeding records were published for five more counties in California (Lassen, Alameda, Santa Clara, Ventura, and Riverside) and one in Oregon (Jackson) (Table 1). And in our survey, we found tricolors breeding in four additional counties in California: Sonoma (near Petaluma), El Dorado (near Salmon Falls Road), Modoc (at Clear Lake National Wildlife Refuge), and Siskiyou (at Lower Klamath and Tule Lake National Wildlife Refuges) (Table 1; Figure 1).

We did not find tricolors breeding in four California counties (Marin, Solano, Santa Cruz, and Fresno) where Neff (1937) reported them, but this does not necessarily mean that breeding has declined in these areas. The colonies he found were relatively small (6 to 500 nests), and our searches were limited to one or two quick drives through each county by road.

TABLE 1. Number and Size of Tricolored Blackbird Breeding Colonies Reported Since 1933 and Found During 1968-1972, by Year and County

County	Year(s)	Colonies (range during years)		Source	
		Number	Size		
Sacramento Valley, California					
Sacramento	32-36	1-3	1,000-121,000 nests	Neff 1937	
	60	2	30,500 nests	Orians 1961a	
Yolo	69-72	6-11	15,850- 50,915 birds	Present study	
	31-36	1-3	2,000- 38,000 nests	Neff 1937	
	39	1	2,000 birds	Lack and Emlen 1939	
Placer	60	1	70,000 nests	Orians 1961a	
	69-72	2	5,000- 31,000 birds	Present study	
	33, 36	1	1,000- 1,500 nests	Neff 1937	
Sutter	71	1	?	Present study	
	32-36	1-3	1,000- 13,000 nests	Neff 1937	
Lake	68	1	25,000 birds	Present study	
	36	1	20 nests	Neff 1937	
Colusa	72	1	2,500 birds	Present study	
	32-34, 36	2-11	3,000- 37,000 nests	Neff 1937	
	59*	1*	19,500 nests	Orians 1960	
El Dorado	59-60	3-4	104,650-156,500 nests	Orians 1961a	
	61*	1*	4,000 nests	Payne 1965	
	63	?	?	Payne 1965	
	69-72	1-4	1,000- 57,000 birds	Present study	
	71	1	800 birds	Present study	
	Yuba	31-36	2-9	2,000-113,000 nests	Neff 1937
		39	4	60,000+ birds	Lack and Emlen 1939
Butte	40	2	22,000 nests	Emlen 1941	
	59*	1*	2,150 nests	Orians 1960	
	59-60	2-3	17,300- 55,000 nests	Orians 1961a	
	62-63	?	?	Payne 1965	
	60-64*	1-2*	100- 400 nests	Payne 1965	
	69-70	1-2	1,000- 5,250 birds	Present study	
	32-36	2-13	3,000-106,000 nests	Neff 1937	
Glenn	60	1	35,000 nests	Orians 1961a	
	61, 64*	1*	100- 150 nests	Payne 1965	
	69-72	1-3	500- 25,000 birds	Present study	
	32-36	3-7	4,000-282,000 nests	Neff 1937	
Tehama	63*	1*	20 nests	Payne 1965	
	63-64	?	?	Payne 1965	
	69-72	1-3	2,000- 18,500 birds	Present study	
	72*	1*	1,000 nests	Present study	
San Joaquin Valley, California	36	1	75 nests	Neff 1937	
	69-70, 72	1	1,500- 2,000 birds	Present study	
San Joaquin	35-36	1-4	100- 3,750 nests	Neff 1937	
	69-72	1-2	500- 5,050 birds	Present study	
Stanislaus	32, 35-36	2-6	8,000- 12,500 nests	Neff 1937	
	69-72	2-7	4,200- 25,300 birds	Present study	
Merced	32-36	1-19	2,000- 58,000 nests	Neff 1937	
	69-72	3-10	12,500- 26,000 birds	Present study	
Fresno	36	1	100 nests	Neff 1937	
	56	1	10,000 birds	AFN † 10(4):362, 1956	
	62, 64	?	?	Payne 1965	
Kings	63*	2*	101 nests	Payne 1965	
	32	1	2,000 nests	Neff 1937	
Tulare	71	1	25,000 birds	Present study	
	35	1	2,000 nests	Neff 1937	
Kern	71	1	1,500 birds	Present study	
	35-36	1-2	500- 2,000 nests	Neff 1937	
	53	1	1,000 nests	AFN 7(4):292, 1953	
	56, 58-60	1-2	200- 2,000 nests	Collier 1968	
	58	1	?	Orians 1961a	
	59	1	600 birds	AFN 13(4):402, 1950	
	71-72	1	2,000- 3,000 birds	Present study	

TABLE 1. Number and Size of Tricolored Blackbird Breeding Colonies Reported Since 1933 and Found During 1968-1972, by Year and County—Continued

County	Year(s)	Colonies (range during years)		Source
		Number	Size	
Northern California—southern Oregon				
Shasta (Ca.)	32-33	2-4	1,000- 18,000 nests	Neff 1937
	72	1	5,000 birds	Present study
Lassen (Ca.)	62	1	?	AFN 16(4):445, 1962
Modoc (Ca.)	70-71	1	125- 250 birds	Present study
Siskiyou (Ca.)	69-72	1-3	250- 10,200 birds	Present study
Klamath (Or.)	33	1	50 nests	Neff 1933
	71	2	180 nests	Present study
Jackson (Or.)	58	1	1,000 nests	AFN 12(4):379, 1958
	60	1	1,800 birds	Richardson 1961
	63	3	40 birds	AFN 17(5):479, 1963
	65	?	100+ birds	AFN 19(5):573, 1965
	70	2	?	Present study
Coastal and southern California				
Marin	33	1	?	Neff 1937
Sonoma	71	4	150- 3,000 birds	Present study
Solano	32	1	6 nests	Neff 1937
Alameda	66	1	4,000 birds	AFN 20(4):545, 1966
	71	3	11,200 birds	Present study
Santa Clara	51	1	?	AFN 5(4):276, 1951
Santa Cruz	32	1	500 nests	Neff 1937
Monterey	32, 36	1-3	2,000- 4,000 nests	Neff 1937
	59	1	400 birds	AFN 13(4):398, 1959
	71	1	5,000 birds	Present study
Santa Barbara	36	1	3,000 nests	Neff 1937
	71	1	1,200 birds	Present study
Ventura	57-59	2-3	175- 1,800 nests	Collier 1968
Los Angeles	36	1	500 nests	Neff 1937
	59-60	1	300- 600 nests	Collier 1968
	71	1	2,500 birds	Present study
Riverside	43, 51	1	2,000 birds	AFN 5(5):309, 1951
	69-71	1-3	5,000- 15,750 birds	Present study
Orange	36	1	250 nests	Neff 1937
San Diego	32, 35-36	1-4	100- 3,000 nests	Neff 1937
	62	1	2,000 birds	AFN 16(4):448, 1962
	64	?	?	Payne 1965
	70-72	1-3	5,000- 9,000 birds	Present study

* Fall breeding colonies.

† AFN = Audubon Field Notes.

In several other areas, we saw flocks of tricolors during the breeding season without finding colonies (Figure 1). At Honey Lake (Lassen County), for example, about 20 males were seen singing in a tree. About 60 tricolors were sighted in a field near Yreka (Siskiyou County), and flocks of 100 to about 1,000 were seen near Chula Vista and near Otay Reservoir (San Diego County); near Los Alamos (Santa Barbara County); near Redding (Shasta County); near Moss Landing and on Hunter Liggett Military Reservation (Monterey County); and in the San Benito River Valley (San Benito County). Published records (Table 1) report tricolor breeding in all of these counties except San Benito.

Geographically, the breeding range of the tricolor has changed little during the past 30 years. Colonies are still found from southern Oregon south through Shasta County, California, and along the coast of California from Sonoma County to the Baja California border. Sporadic breeding also occurs in the plateau region of northeastern California and in the northwestern extremity of the Mojave Desert, but by far the majority of tricolors still breed within the Central Valley.

General Habitat

Within the Central Valley, breeding colonies were generally found in two major agricultural types—the rice lands of the Sacramento Valley and the pasturelands of the lower Sacramento Valley and San Joaquin Valley. In the rice lands, the annually flooded rice is the dominant crop, but small grains, hay, safflower, sugar beets, corn and beans are also grown. The pasturelands consist largely of irrigated fields of introduced grasses, alfalfa (grown for seed), hay, and small grains. In both areas, insects in flooded fields probably provide the primary food for breeding tricolors (Crane and DeHaven, manuscript in prep.).

Colonies outside the Central Valley were in several different habitat types. For example, at East Park Reservoir (Colusa County) and near Alberhill (Riverside County), breeding areas were surrounded by chaparral covered hills extending for several miles in all directions. A colony near Fallbrook (San Diego County) was surrounded by several hundred acres of orange and avocado groves interspersed with grass-covered hills a few acres in size. Two colonies in Alameda County were adjacent to the salt-marsh habitat of San Francisco Bay. At Clear Lake National Wildlife Refuge and at the Lava Beds National Monument (Siskiyou County) colonies were in sagebrush-grasslands.

Two southern California colonies probably best illustrate the tricolor's ability to breed under widely varying environmental conditions. A colony of about 2,500 adults was nesting in a small agricultural area near Del Sur (Los Angeles County), which is on the western edge of the Mojave Desert, and a group of several small colonies was found within the city limits of Santa Barbara (Santa Barbara County), about 274 m (300 yards) from the Pacific Ocean. Of the two sites, the desert breeding is probably more unusual, since the tricolor has apparently not invaded the man-made agricultural environment in the desert of the Coachella Valley (Riverside County), although less than 121 km (75 miles) of semi-desert separates the area from other breeding sites.

Nesting Substrate

The vegetation in which nests were built was recorded for 156 colonies (Table 2). Of these, 108 (69%) had nests built in some kind of marsh vegetation—cattails (*Typha* sp.), bulrushes (*Scirpus* sp.), willows (*Salix* sp.), or some combination of these, and 76 (49%) were in cattails only. Other workers have also reported marsh vegetation as the major nesting substrate. In particular, of 256 colonies Neff (1937) found, 246 (96%) were in cattails, willows, and bulrushes. Orians (1961a) reported that 16 (64%) of the 25 colonies in the Sacramento Valley were in cattails and other emergents. And Collier (1968) found 27 (84%) of 32 southern California colonies in marshes or riparian willows.

The size, configuration, and plant density of the marshes used for nesting were extremely variable. Near Red Bluff (Tehama County), a 1,500-bird colony nested for 2 consecutive years in a burned-over cattail marsh where the vegetation was less than 0.9 m (3 ft) tall and nearly too sparse to support the nests (which were often only a few inches above the water); near Modesto (Stanislaus County) a colony of more than 1,000 birds nested in a strip of cattails only 3 m (10 ft) wide and 22.9 m (75 ft) long; near Arbuckle (Colusa County) adults nested in 3.7 m (12 ft) tall bulrush and cattail that was too thick for a man on foot to penetrate. In general, we observed no preference for a particular shape of marsh such as the broad circles or irregular polygons that Collier (1968) thought tricolors preferred.

We also found tricolors nesting in blackberry (*Rubus* sp.), mustard (*Brassica campestris*), thistle (*Centaurea* sp.), nettle (*Urtica* sp.), safflower (*Carthamus tinctorius*), and giant reed (*Arundo donax*) (Table

TABLE 2. Number of Tricolored Blackbird Breeding Colonies by Nesting Substrate, 1968-1972

Nesting substrate	Number of breeding colonies found					Total (%)
	1968	1969	1970	1971	1972	
Cattail.....	2	13	20	28	13	76 (48.7)
Cattail, bulrush.....	1	2	7	8	5	23 (14.7)
Blackberries.....	--	6	4	11	4	25 (16.0)
Willows.....	--	1	1	3	--	5 (3.2)
Bulrush.....	1	1	1	2	2	7 (4.5)
Mustard, thistle.....	--	1	1	3	--	5 (3.2)
Thistle.....	--	--	--	2	--	2 (1.3)
Giant reed.....	--	--	2	1	3	3 (1.9)
Mustard.....	--	1	1	--	1	3 (1.9)
Nettles.....	--	1	--	1	--	2 (1.3)
Cattail, bulrush, willows.....	--	--	--	2	--	2 (1.3)
Mustard, safflower.....	--	--	--	1	--	1 (0.6)
Nettles, willows, blackberries.....	--	--	1	1	--	2 (1.3)
Total.....	4	26	36	64	26	156 (99.9)

2). We know of no previous report of nesting in giant reed, although tricolors nested in this at least three times during our study (near Manteca, San Joaquin County, where 3,000 birds nested in 1971 and 1972, and near Del Sur where the 2,500-bird colony mentioned earlier nested near the desert).

Altitudinal Dispersion

Neff (1937) found colonies from sea level near San Diego and Santa Cruz to about 1,280 m (4,200 ft) on Klamath Lake. More recently, Collier (1968) reported a colony near Tehachapi (Kern County) at 1,158 m (3,800 ft) and Audubon Field Notes (16: 445, 1962) reported a colony near Susanville (Lassen County) at slightly over 1,219 m (4,000 ft). We found a similar altitudinal dispersion, with colonies ranging from sea level in Santa Barbara and near Alameda (Alameda

County) to 1,362 m (4,469 ft) at Clear Lake National Wildlife Refuge. However, altitudes in the Central Valley, where most colonies are located, are only about 6.1 to 121.9 m (20 to 400 ft) and those in the high-density tricolor breeding areas in Merced, Stanislaus and Sacramento counties (Figure 1) are only about 18.3 to 30.5 m (60 to 100 ft).

Fall Breeding

Although we were aware of possible fall breeding by tricolors in the Sacramento Valley (Orians 1960; Payne 1965), and in fact searched for colonies several times, we found only one instance of fall breeding. This was a colony of about 1,000 nests apparently all unsuccessful, in a cattail pond on the Sacramento National Wildlife Refuge (Glenn County) during November 1972. We do not know if fall breeding occurred in other parts of the species' range.

SIZE OF COLONIES

Numbers of Birds

We estimated the number of breeding birds at 157 colonies (Table 3). Of these, about 25% had fewer than 1,000 birds, about 62% had from 1,000 to 10,000 birds, and 13% had more than 10,000 birds.

TABLE 3. Number of Tricolored Blackbird Breeding Colonies by Size Classes, 1968-1972

Size class (number of breeding birds)	Year					Total (%)
	1968	1969	1970	1971	1972	
Fewer than 1,000.....	--	1	11	20	8	40 (25.5)
1,000 to 9,999.....	2	17	25	36	17	97 (61.8)
10,000 to 25,000.....	2	8	--	7	2	19 (12.1)
More than 25,000.....	--	--	--	--	1	1 (0.6)
Total.....	4	26	36	63	28	157 (100.0)

The smallest colony, 15 birds, was observed in 1971 near Folsom (Sacramento County). All large colonies were in the Central Valley. The largest, about 30,000 birds, was observed in 1972 near Knights Landing (Yolo County). Others, each containing about 20,000-25,000 birds, were: near Tudor (Sutter County) in 1968; near Colusa in 1969 and 1971 and near Dunnigan in 1969 (Colusa County); near Clay and near Galt in 1971 (Sacramento County); near Corcoran (Kings County) in 1971; and near Knights Landing in 1969.

The colonies outside the Central Valley all contained fewer than 10,000 tricolors. West of the valley, for example, the three largest colonies were in the San Francisco Bay area (Alameda County), and each had about 5,000 breeding birds. North of the valley, the largest colony had about 1,250 birds at Tule Lake National Wildlife Refuge.

TABLE 4. Nesting Densities of Tricolored Blackbirds in Breeding Colonies by Nesting Substrate, 1968-1972

Nesting substrate	Number of colonies	Area occupied by nests (acres)		Number of birds per acre*		Number of active nests per acre*	
		Range	Average	Range	Average	Range	Average
Giant reed.....	2	0.01- 0.25	0.17	12,000-200,000	106,000	8,004-133,340	70,670
Blackberries.....	15	0.02- 1.25	0.41	750-100,000	24,532	500- 66,670	16,355
Mustard.....	2	0.25- 0.33	0.29	700- 1,000	8,500	407- 667	5,667
Mustard, thistle.....	6	0.05-10.00	1.80	400- 30,000	7,240	267- 20,000	4,827
Willow trees.....	5	1.00- 2.33	1.67	1,000- 30,000	6,550	667- 13,340	4,367
Cattails and/or bulrush.....	77	0.05-10.00	1.62	400- 30,000	5,024	267- 20,010	3,350
Thistle.....	1	---	1.25	---	3,000	---	2,000
Mustard, safflower.....	1	---	0.04	---	313	---	209
Total.....	109						

* Some bird census figures were estimated from nest counts and some nest density figures from bird counts; these estimates were based on a male:female ratio of 1:2 and a female:active nest ratio of 1:1.

(About 10,000 tricolors were reported there early in the spring of 1969, but the birds apparently did not all nest in one colony.) South of the valley, the largest colony was about 2,500 birds in San Diego County. A cooperator reported that a colony of about 10,000 birds nested near Temecula (Riverside County), but we did not confirm this estimate.

Nesting Area and Density

The number of birds or nests and the area they occupied were estimated for 109 colonies (Table 4). Nesting areas varied widely with the size of the colony and the type and size of the local nesting substrate, but generally nests were built in only a fraction of the total area available. Also, areas occupied by more or less continuous nesting were smaller in upland habitats than in marshes. Continuous nesting areas in blackberries averaged .17 ha (0.41 acre); in all other upland types they averaged .33 ha (0.82 acre). In contrast, nesting areas in marshes averaged .65 ha (1.62 acres). In several marshes, nesting was nearly continuous on at least 1.6 ha (4 acres) of the available habitat. The largest areas of continuous nesting recorded were on about 4.1 ha (10 acres) of mustard and thistle in Alameda County where 5,000 birds nested, and on 10 acres of cattails (part of a 10.1 ha (25-acre) marsh) in Colusa County where more than 20,000 birds nested.

The greatest nesting density was at the Del Sur colony, where 2,500 tricolors built nests in an area of giant reed only about 12.8 x 3.9 m (42 x 13 ft) (1/80 acre); this is equivalent to about 200,000 birds, or 133,340 nests, per acre. Two sites with extremely sparse nesting densities were a 15-bird colony at Folsom (in blackberries), and a 50-bird colony at Tule Lake National Wildlife Refuge (in mustard and thistle), where densities were only about 750 birds per acre. Overall, nesting was densest in giant reed and blackberries; intermediate in mustard, mustard-thistle, and willow; and sparsest in cattails, bulrush, and combinations of these (Table 4).

POPULATION SHIFTS

Seasonal

Colony abandonment provided evidence of population shifts during the nesting seasons. During the survey, we made repeated visits to about one-third of all the colonies found, and of these, about 10% to 50% were partially or completely abandoned each year. The observed abandonment occurred throughout each nesting season, although, like Neff (1937), we observed it more often early in the year. In April 1970, for instance, we found about 10,000 tricolors at four breeding colonies in southeastern Sacramento County. The birds were building nests or incubating eggs. Within a few days, all four had been abandoned, and there was no later breeding in the area that year. Abandonment likely is related to insufficient food supplies for the breeding birds and their young (Lack 1954; Orians 1960, 1961a).

Yearly

We also observed substantial yearly variation in the centers of breeding abundance. In several counties in the Central Valley where man-days spent searching was fairly constant each year from 1969 through

1972, the number of colonies and breeding birds usually differed greatly between years (Tables 1 and 5). For example, in 1969 at least 57,000 tricolors nested in Colusa County, but in 1970 there were only about 2,000. Similar fluctuations occurred elsewhere in the Central Valley.

Neff (1937), Orians (1961b), and Orians and Collier (1963) also reported that the breeding distribution of the tricolor was somewhat unpredictable from year to year. Orians (1960; 1961a), however, stated that the tricolor's center of breeding abundance and the largest colonies were in the rice-growing area of the Sacramento Valley. Our data show that this is not true for all years. Only 5 of the 10 largest colonies of our study were in the major rice district. Furthermore, in 1969 and 1972 about 58% and 59% of all the breeding tricolors were in five major rice-growing counties, but in 1970 and 1971 only about 32% and 29% were (Table 5). In 1971 we found only 49,000 tricolors nesting in the five major rice counties, compared to the largest breeding population (about 51,000 birds) which nested within a few square miles in the pasturelands of southeastern Sacramento County.

These yearly shifts, which are likely related to insect supplies and other, unknown, breeding requirements, may operate as follows: During winter, many tricolors leave the Sacramento Valley rice areas. Probable major wintering areas are the San Francisco Bay-Delta area and the northern San Joaquin Valley (Neff 1937, 1942; Orians 1961a; Payne 1965; and DeHaven et al., manuscript in prep.). When spring arrives, tricolors disperse from these wintering areas to search out sites with the proper requirements for breeding, of which an abundance of insects is probably most critical (Orians 1961a; Orians and Collier 1963; Payne 1965; and Lack 1954). Movement is probably mainly northward from wintering locations because areas with acceptable nesting substrates are relatively scarce in the arid southern San Joaquin Valley.

Although population shifts occurred each year, there were a few local areas, such as the pasturelands in Merced County near Gustine and Los Banos and in Stanislaus County along the San Joaquin River, where breeding was somewhat regular and predictable. Neff (1937) also found regular breeding in the Merced County area which, judging from his descriptions, seems to have changed little. However, probably the most consistently used area during our study was the pasturelands in southern Sacramento County, where we found 6, 8, 11, and 4 colonies during the years 1969-1972.

A few specific breeding sites outside of the Central Valley were regularly used. A cooperator reported that near Temecula a colony was active during 1967-1971. Colonies at Tule Lake and Lower Klamath National Wildlife Refuges were active during all years of the study. A land owner reported that one of the colonies we found near Santa Barbara had been active for at least 25 years, and according to Bent (1965), Nuttall first described the species from this or a nearby area in 1836, and listed it as common in April.

TABLE 5. Number of Tricolored Blackbirds Breeding in Major Rice-Growing Counties of the Sacramento Valley, California, 1969-1972

Year	Number of breeding birds found						Percent total found in major rice counties
	In all counties	Colusa	Butte	Glenn	Yolo	Yuba	
1969	181,000	57,000	20,000	2,000	25,000	1,000	105,000
1970	84,850	2,000	1,500	18,900	5,000	5,250	32,250
1971	167,540	26,000	2,500	5,500	15,150	--	49,150
1972	97,850	25,000	500	1,000	31,000	--	57,500
Total	532,040	110,000	24,500	27,000	76,150	6,250	243,900

* No colonies were found in Sutter County, a major rice-growing area, during 1969-1972.

LONG-TERM POPULATION CHANGES

The findings of our survey were similar in many respects to those of Neff (1937) who first studied tricolor populations some 35 years earlier. There were, however, several striking differences:

1) We found fewer colonies than Neff (1937). During 6 years of study (1931-1936), he devoted an average of about 31 man-days a year to specific searches for tricolor colonies, and listed a total of more than 256. (His listing, like ours, included a few records supplied by cooperators.) Even with our better transportation, more roads providing access to colonies, and about 45 man-days a year specifically devoted to searches, in 4 years we found only 164 colonies.

2) We saw fewer non-breeding tricolors than Neff (1937). He estimated that "unattached bands observed during the [6 years of] field work totaled considerably more than 50,000 birds." During 4 years, we observed fewer than 15,000.

3) We did not find any nesting areas approaching the size of some Neff (1937) reported. For example, he described a large colony in Glenn County where the birds were "active [in nest building] over an area roughly 6.4 km (4 miles) east and west by 9.6 km (6 miles) north and south." He estimated that another colony in Glenn County contained at least 260,000 nests and covered virtually 24.3 ha (60 acres). Our most extensive colonies had continuous nesting over only about 4 ha (10 acres). (One large colony of about 25,000 birds was found in a 32.3-ha (80-acre) safflower field, but we do not know if nesting was continuous throughout the field. The colony was abandoned during egg-laying.)

4) Our largest colonies apparently contained far fewer birds than Neff's (1937). He listed five colonies with at least 75,000 nests (equivalent to about 112,500 birds). Our largest colony contained only about 30,000 birds, and fewer than 20,000 of these actually completed their nesting cycle. In attempting to estimate the population of his largest colony (in Glenn County), Neff "gave up in despair with the thought that an estimate of 250,000 adults was ridiculously low." This figure is considerably larger than the highest yearly total we recorded for all colonies (181,800 birds), in 1969.

5) We found fewer total tricolors than Neff (1937). During his 6 years of study, he found more than 1.5 million nests, equivalent to more than 2.2 million breeding birds, or more than 375,000 a year. During 1969-1972, we found about 532,000 breeding birds, or about 133,000 a year. The difference was especially obvious in the major rice-growing counties (Butte, Colusa, Glenn, Sutter, Yolo and Yuba) of the Sacramento Valley where Neff (1937) found all of his very large colonies, and an average of about 161,000 nests, or more than 241,000 breeding birds a year. In comparison, our 4-year total for the major rice-growing counties was about 244,000 birds (Table 5).

Tricolors have apparently not benefited from increasing rice culture in the Central Valley as suggested by Neff (1937) and Orians (1961a, 1961b). Rice acreages have increased nearly fourfold during the last 30 years, from about 50,625 ha (125,000 acres) during the 1940's to nearly 202,500 ha (500,000 acres) in 1954, then down to 91,530 ha

(226,000 acres) in 1957, and finally to 174,960 ha (432,000) acres in 1968 (Johnston and Dean 1969). Thus, if rice culture is beneficial to the tricolor, then this benefit must have been offset by one or more detrimental factors. Perhaps the increase in land use and intensified pesticide use in recent years have limited the food supplies essential for tricolor breeding.

There is no question that suitable nesting habitat for tricolors has been lost in some local areas. For example, Neff (1937) and later Lack and Emlen (1939) studied colonies near Davis (Yolo County), but little or no nesting habitat exists there now and we found no breeding. There is now no nesting habitat near Riego Road in Sacramento County where Orians (1961a) found several colonies. South of the Central Valley, Collier (1963) studied colonies at Cache Creek (Kern County), which has since been covered by a freeway, and at San Fernando Reservoir (Los Angeles County), which has been drained for housing development. Nevertheless, we doubt that local losses of habitat have contributed significantly to any overall population decline. In fact, like Neff (1937), we found that tricolors in most areas, including the Sacramento Valley, leave many marshes and other apparently suitable nesting sites unused each year. Clearly, further research on the requirements for tricolor breeding is needed to help isolate a possible cause for the species' apparent decline.

Also important are the questions of when the decline began and whether it is continuing. Unfortunately, none of the studies conducted between Neff's (1937) and ours are complete enough to draw conclusions about total population size in even a portion of the tricolors' range. However, if significant observer differences can be ruled out, the fact that Orians (1961a) found three colonies with 50,000 to 100,000 nests in the Central Valley as recently as the early 1960's could indicate that the decline is relatively recent. Further research is needed to determine whether this downward trend, which may have reduced the Central Valley population by more than 50%, is continuing, and whether it has yet reached the point of concern.

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THE AGE AND GROWTH OF THE PACIFIC BONITO, *SARDA CHILIENSIS*, IN THE EASTERN NORTH PACIFIC¹

by

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An age and growth study of the Pacific bonito, *Sarda chilensis*, was conducted between 1968 and 1973. Otoliths were used to establish the ages of over 3,000 bonito, and the results verified by length frequency samples, a tag and recapture experiment, and back-calculation of mean length at each age. The results show that bonito grow rapidly during their first 3 years of life, with much slower growth from 3 to 6 years old. The mean length of each age group in the fishery is: age I—51.5 cm (20.3 inches), age II—63.3 cm (24.9 inches), age III—69.5 cm (27.4 inches), age IV—72.9 cm (28.7 inches), age V—74.8 cm (29.4 inches), and age VI—75.7 cm (29.8 inches).

INTRODUCTION

The Pacific bonito is an epipelagic schooling fish found along the Pacific coast of both North and South America. This tuna-like species is discontinuously distributed from Chile to the Gulf of Alaska, being absent from the central coast of Mexico south into Panama. In the North Pacific the species is most economically productive from Magdalena Bay in southern Baja California to Point Conception, California. The growing importance of this species after 1957 in the California sport and commercial catch has emphasized the need for information on which to base management decisions.

During the early years, commercial fishermen using purse seines and trolling gear averaged about 2,000 metric tons per year (Heimann and Carlisle 1970). Commercial landings increased dramatically after 1966, reaching 13,900 metric tons (MT) (15,400 short tons) in 1973 (Oliphant 1974), and averaging about 8,800 MT per year (9,700 short tons), primarily because of increased demand for the canned product.

During the decade between 1947 and 1956 sport anglers using rod and reel caught an average of 46,000 bonito per year. The bonito sportcatch started on the upswing with the onset of anomalous warm water years in the California Current system in 1957 (Radovich 1961). For unknown reasons, when the ocean waters off California returned to cooler temperatures after 1960, the catch of bonito remained high. In the years between 1960 and 1972 the sport catch averaged about 1 million fish per year and reached a record of about 2.5 million fish in 1964 (Thayer 1973). By 1968 bonito were ranked as the fourth most important species to the partyboat industry (Young 1969). The peak sportcatch of bonito occurs during August and September, however, it gains exceptional recognition during the winter months when the young

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