

MOSQUITOES COLLECTED ON CALIFORNIA OFFSHORE ISLANDS¹

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ABSTRACT. Surveys were made to determine what species of mosquitoes were present on several offshore islands of California from November 1967 through April 1970. The island habitats are principally of two types: (1) Woodland-chaparral, and (2) shrub-grassland with some barren land. Eleven mosquito species were found on the woodland-chaparral islands: *Aedes sierrensis* (Ludlow), *A. squamiger* (Coquillett), *Anopheles pseudopunctipennis franciscanus* McCracken, *Culex apicalis* Adams, *C. erythrothorax* Dyar, *C. peus* Speiser, *C. quinquefasciatus* Say, *C. tarsalis* Coquillett, *C. thriambus* Dyar, *Culiseta*

incidens (Thomson), and *C. inornata* (Williston). Only three species were found on the shrubland-grassland islands: *C. tarsalis*, *C. incidens*, and *C. inornata*. A small number of blood-meal identifications made from engorged *C. incidens* and *A. p. franciscanus* indicated that both species had fed on bovines and equines. A number of biting midges (Ceratopogonidae) also were collected; these were of the following species: *Culicoides cacticolus* (Wirth and Hubert), *C. sitiens* Wirth and Hubert, *C. copiosus* Root and Hoffman, *C. baueri* Hoffman, *C. freeborni* Wirth and Blanton, and *Culicoides* subgenus *Selfia*.

INTRODUCTION. Surveys were made on islands off the California coast to determine mosquito species that were present and whether they are likely to pose public health problems. Island visits were intermittently made from November 1967 through April 1970. Some of the blood-engorged females obtained were tested by micro-precipitin technique to identify the types of animals on which they had fed.

The islands surveyed were San Clemente and Santa Catalina in Los Angeles County, San Nicolas and Anacapa in Ventura County, and Santa Cruz and Santa Rosa in Santa Barbara County. These islands range from 12 to 61 miles from the mainland and they are members of the Channel Islands group that extends 130 miles from San Diego northward to Point Conception (Fig. 1). One visit also was made to South Farallon Island which is 25 miles west of San Francisco. The islands are described and discussed

by Gleason (1958) and by Hillinger (1958).

This report lists the species of mosquitoes collected on the various islands and provides information obtained on the blood-feeding habits of two species.

PROCEDURES. Adult mosquitoes were collected with a D-Vac, CDC sweeper, flashlight aspirator, New Jersey light trap and CDC miniature light traps. Larvae and pupae were collected by dipping and either preserved in 70 percent ethyl alcohol or brought to the laboratory for rearing, and then identified to species.

Blood suspensions were made from the more fully-engorged female mosquitoes found and tested with antisera that had titers against a wide variety of animal species. The antisera were prepared by standard immunologic techniques described by Tempelis (1962) and Tempelis and Reeves (1962). The blood meal determinations were performed as previously described by Tempelis and Lofy (1963).

RESULTS. San Clemente Island. San Clemente Island is a U. S. Navy reservation and lies 50 miles off the mainland of California. It is 20 miles long and 4 miles wide. Much of its surface consists of gentle slopes covered with grasses, although shrubs are present in the coastal canyons. Sand dunes cover the northwest part of the island. The island flora was described by Dunkle (1950) and by Raven (1963).

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During January 16-18, 1968, larvae and pupae of *Culiseta incidens* (Thomson) and *Culiseta inornata* (Williston) were found on the southeast part of San Clemente Island. They were collected from fresh water pools that were behind abandoned earth and concrete dams, in seepage adjacent to larger bodies of fresh water and in the channel of an old spillway. Although no mosquitoes were attracted into light traps that were operated during a calm and warm night, 2 female midges were collected in one trap and identified as *Culicoides cacticolus* (Wirth and Hubert).

A second survey was made on San Clemente Island from April 29, 1969 to May 1, 1969. At this time *C. incidens* larvae were found in a small, clear pool of fresh water at the cantonment at Wilson Cove. Adult *C. incidens* were collected from the acclivity of a dry ravine near an unused reservoir about 10 miles southeast of the cantonment.

Santa Catalina Island. Santa Catalina Island, 20 miles off the coast, is 18 miles long and 7 miles wide. The topography of the island includes wooded slopes and canyons as well as rolling grasslands and valleys.

A survey was conducted on Santa Catalina Island from November 13-15, 1967. During this period, larvae of *Culex apicalis* Adams, *Anopheles pseudopunctipennis franciscanus* McCracken and *C. inornata* were collected in stream pools just below Thompson Reservoir. A livestock watering reservoir near El Rancho produced *Culex tarsalis* Coquillett and *A. p. franciscanus* larvae. The only adult mosquito found during this visit was an empty female *A. p. franciscanus*, and it was collected from under the eaves of a building at Eagle's Nest Lodge.

The second survey on Santa Catalina Island was conducted July 17-19, 1968. Shelter collections were made inside wooden buildings at Middle Ranch and

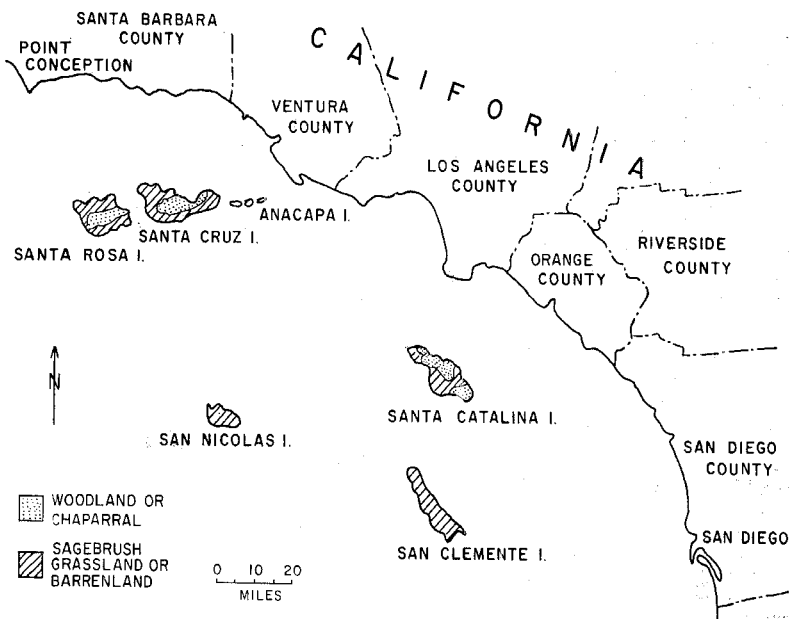


FIG. 1.—The California Channel Islands surveyed.

the resort town of Avalon, in culverts at Thompson Reservoir and Avalon, under the eaves of buildings at Eagle's Nest Lodge and under a wooden bridge west of the lodge. A collection was also made on vegetation 2.5 miles west of Avalon. Collectively, the mosquito species found were: *Culex peus* Speiser, *C. apicalis*, *C. quinquefasciatus*, *C. tarsalis*, *A. p. franciscanus*, *C. incidens*, and *Aedes squamiger* (Coquillett). Breeding of all these species, except *A. squamiger*, was found in effluent water originating from a laundry and collecting in a small drain ditch in Avalon; in a leaf-bottom and partly moss-covered pool at the outlet of Thompson Reservoir; in small turbid pools of water originating from a broken pipe near a reservoir 2 miles west of Avalon; 2.5 miles west of Avalon in water that was dripping from a faucet and pooling in animal hoof tracks; in a bog near a wooden bridge northwest of Eagle's Nest Lodge, or in a cattle watering trough near El Rancho Escondido. *Culex quinquefasciatus* Say and *A. p. franciscanus* were obtained from light traps that were operated at Avalon, Eagle's Nest Lodge and Middle Ranch.

Two fully blood-engorged specimens of *A. p. franciscanus* were collected during the July 1968 survey, and they had fed on equine and bovine hosts.

San Nicolas Island. San Nicolas Island is a U. S. Navy reservation 61 miles off the California coast. It is 8 miles long and 3 miles wide. The interior is a rolling mesa and much of the island cover is comprised of grasses, some shrubs and sand dunes.

A survey was made on San Nicolas Island from March 27-29, 1968, and a single *C. tarsalis* larva was collected from a springwater pool on the north shore of the island. *Culiseta inornata* larvae were found in fresh water seepage in an earth-floor sump at the cantonment. No adult mosquitoes were found during this visit.

During a survey conducted November 19-22, 1968, a *C. tarsalis* and two *C. inornata* were collected on vegetation in a fresh water ravine near the northeast tip

of the island. An additional *C. inornata* specimen was collected on vegetation in a freshwater bog at Thousand Springs. No mosquito breeding was found during this survey and no adult specimens were collected in a light trap that was operated for 2 nights at the cantonment.

No mosquitoes were found during a third survey conducted April 8-9, 1970 on San Nicolas Island.

Anacapa Island. Anacapa Island is a chain of three small islands that are commonly referred to as East, Middle, and West Islands, and they are 12 miles from the mainland. These precipitous islands extend 4.5 miles from east to west. Middle Island is separated from East Island by a rock-strewn gap and from West Island by a 50 foot water passage. The predominant vegetation on Anacapa is grasses and shrubs; however, a few eucalyptus trees are present there.

East Island is a mile long and one-fourth mile wide. U. S. Coast Guard personnel were stationed on the island during the first mosquito survey but all resident personnel had been removed before the second visit was made.

C. inornata larvae were obtained on East Island during a survey conducted December 6-10, 1967. The specimens were collected from water that had collected in a small reservoir, a sump, pits dug in the earth and house basements. No adult mosquitoes were collected during 3 nights of light-trapping, possibly due to prevailing strong winds. However, 1 male and 7 female *Culicoides cacticolus* were collected in the traps.

During the second survey on East Island, January 18, 1969, only one mosquito was found, and it was an adult *C. inornata* that was collected on vegetation near some abandoned buildings. No larvae were found during this visit.

Middle Island is 1.5 miles long and .5 mile wide. On January 14, 1969, one adult *C. inornata* was collected in a small ravine near some eucalyptus trees on the north-facing slope of the island.

West Island is 2 miles long and .5 mile

wide. The limited survey on the island was conducted on October 4, 1968 near a campsite on the north shore and no mosquitoes were found.

Santa Cruz Island. Santa Cruz Island, the largest of the Channel Islands, is 21 miles long and 6 miles wide and stands 19 miles from the mainland of California. Trees, other large woody plants and grasses cover much of the island's rugged mountains and rolling hills.

A survey conducted March 12-14, 1968 on Santa Cruz island resulted in larval and pupal collections of *C. incidens* and *C. peus*. These two species were found breeding in artificial containers, cattle tracks, and cattle watering troughs near the Navy installation, at the Main Ranch and at the University of California field station. Larvae of *C. apicalis* and *A. p. franciscanus* were collected in water troughs at the Main Ranch. *Aedes sierrensis* (Ludlow) larvae and pupae were found in tree holes in a ravenwood grove about 1 mile north of the field station. No adult mosquitoes were found in shelters or collected in light traps that were operated at the field station and at the Main Ranch, possibly because of the unusually cool nights. However, 19 female *Culicoides* were collected and identified as *C. cacticolus*.

Another survey on the island was conducted September 17-20, 1968. Larvae and pupae of *C. incidens* and larvae of *C. peus*, *C. apicalis*, *C. erythrothorax* and *A. p. franciscanus* were found in a spring on La Cuesta Grade and in the stream at Christi Ranch. One *A. p. franciscanus* larva was collected in a water trough in a draw immediately south of the field station. Adult *C. incidens*, *C. apicalis*, *C. peus*, and *A. p. franciscanus* were found on vegetation and in crevices in a natural spring-fed ravine on a slope opposite the field station, on vegetation in the stream bed at Christi Ranch or inside and under buildings at the field station. Adult *A. p. franciscanus*, *C. incidens* and *C. tarsalis* were obtained from a light trap operated at the field station.

Representatives of the *Copiosus* group of *Culicoides* which are known to breed in decaying cactus (Wirth and Hubert, 1960) all were found in light trap collections. These included *C. cacticolus*, *C. sitiens* Wirth and Hubert, and *C. copiosus* Root and Hoffman. Small numbers of *C. baueri* Hoffman, *C. freeborni* Wirth and Blanton and the *Culicoides* subgenus *Selfia* were also collected.

Ten fully blood-engorged mosquitoes were obtained during the second survey. Four specimens of *A. p. franciscanus* were tested and three had fed on horses and one on bovine. Three of 6 *C. incidens* had fed on horses and three on cattle.

A third visit to Santa Cruz Island was made April 6-7, 1970. During this time one female *A. sierrensis* was collected biting a man near the field station. Larvae of *C. apicalis*, *C. peus*, *C. thriambus* Dyar, *C. incidens*, and *C. inornata* were obtained from ground pools and artificial containers near the station.

Santa Rosa Island. Santa Rosa Island lies 28 miles from the mainland and is 15 miles long and 10 miles wide. The island's high mountains, rolling hills, and valleys are covered with grasses, trees or other large woody plants.

The only survey on Santa Rosa Island was made April 17-19, 1969. *C. incidens* was the only mosquito species found and all specimens were collected in the vicinity of the ranch buildings on the north side of the island at Bechers Bay. Adults were collected on vegetation along the stream, under buildings and by means of a light trap that was operated in the creek bed. Larvae and pupae were found in pools of water associated with the stream.

Twenty-six blood-engorged *C. incidens* were found and all had fed on cattle.

Southeast Farallon Island. Southeast Farallon Island, 25 miles west of San Francisco, is a mile long and .5 mile wide. The terrain is rocky and herbaceous plants are the predominant vegetation. The island is a bird sanctuary for a large number of pelagic birds.

During the March 5-11, 1969 survey,

only one mosquito was found, and it was an adult *C. inornata*. The specimen was dead and hanging from a spider web in a shed at the east landing. Because of very strong winds, a light trap was operated only one night and with negative results.

Table 1 shows that the percent of the potential mosquito-collecting sites that were positive for mosquitoes was considerably higher on the woodland-chaparral islands than on the shrubland-grassland islands. Similarly, mosquitoes were collected during 5 of 8 nights of light trapping on the former habitat type and no mosquitoes were obtained during 7 nights of operating light traps on the shrubland-grassland islands.

Table 2 lists the California islands surveyed during this study, their habitat types, and the species of mosquitoes collected. The greatest geographic distribution of mosquito species was found for *C. inornata*, *C. incidens* and *C. tarsalis*, and these were found in both the woodland-chaparral and shrubland-grassland habitats. The species most commonly collected were *C. incidens*, *A. p. franciscanus* and *C. peus*.

DISCUSSION AND CONCLUSION. The mosquito surveys herein reported were made from November 1967 through April 1970, and the results generally add to the knowledge of species distribution. However, it is realized that species other than those reported here might have been present, but undetected, on the islands. Many of the adult specimens obtained were de-

posited in the museum at San Jose State College, San Jose, California. The larvae collected in the 1970 survey on Santa Cruz Island are in the museum of the Ft. Collins, Colorado Laboratory of the U. S. Public Health Service.

Although shrubs and grasses are present on all of the islands surveyed during this study, the islands may be grouped into two general habitat types: One type represents a richer natural flora that includes woodland and chaparral vegetation and the other is almost exclusively shrubland (sagebrush), grassland and barren land. The islands that represent the former habitat have deeper canyons, higher mountains and more water than the shrubland-grassland habitat islands. They further differ in that they are privately owned and support a relatively large number of cattle.

The woodland-chaparral habitat islands visited are Santa Catalina, Santa Cruz, and Santa Rosa. Eleven mosquito species were found on these islands: *Aedes squamiger*, *A. sierrensis*, *Culex apicalis*, *C. erythrothorax*, *C. peus*, *C. quinquefasciatus*, *C. tarsalis*, *C. thriambus*, *Culiseta incidens*, *C. inornata*, and *Anopheles p. franciscanus*. Nine species were found on Santa Cruz Island, 8 species on Santa Catalina and only a single species was detected on Santa Rosa. It would seem that the single collection made on Santa Rosa Island before the onset of warm weather might explain the paucity of our collections from

TABLE 1.—Comparison of mosquito availability on woodland-chaparral and shrubland-grassland habitat islands of California.

Type of island habitat	Collecting methods					
	Dipping		Hand-operated equipment		Light traps	
	Number breeding sites examined	Percent positive	Number resting sites examined	Percent positive	Light trap nights	Percent positive
Woodland-chaparral	58	43.1	42	40.4	8	62.5
Shrubland-grassland	82	18.2	42	14.2	7	0

TABLE 2.—Mosquitoes collected on California islands from November 1967 through April 1970.

Type habitat-location	Date	Species	Mosquitoes collected				
			No. immatures		No. adults		
			Larvae	Pupae	M	F	
Wood-chaparral							
Santa Catalina	11/13/67	<i>Culex apicalis</i>	23	..	..	..
		<i>C. tarsalis</i>	16	..	..	..
		<i>Anopheles p. franciscanus</i>	15	..	..	1
	7/17/68	<i>Culiseta inornata</i>	15	..	..	..
		<i>A. p. franciscanus</i>	17	2	41	541	
		<i>Culex peus</i>	144	10	1	5	
		<i>C. tarsalis</i>	94	5	2	..	
		<i>C. quinquefasciatus</i>	22	2	8	7	
		<i>Culiseta incidens</i>	20	1	1	6	
		<i>Culex apicalis</i>	3	..	5	2	
			<i>Aedes squamiger</i>	..	..	1
	Santa Cruz	3/12/68	<i>C. incidens</i>	102	15
			<i>C. peus</i>	75	9
<i>Aedes sierrensis</i>			19	2*	..	..
<i>A. p. franciscanus</i>			7	..	..	..
9/17/68		<i>C. apicalis</i>	2	..	..	..
		<i>C. incidens</i>	86	2	18	47	
		<i>C. apicalis</i>	1	..	14	9	
		<i>A. p. franciscanus</i>	4	..	1	13	
		<i>C. peus</i>	1	..	1	4	
4/6/70		<i>Culex erythrothorax</i>	3	..	..	..
		<i>C. tarsalis</i>	..	..	..	1
		<i>C. incidens</i>	22	..	..	..
		<i>C. apicalis</i>	7	..	..	..
		<i>C. peus</i>	6	..	..	..
		<i>C. thriambus</i>	2	..	..	..
	<i>C. inornata</i>	1	..	..	..
		<i>A. sierrensis</i>	..	..	1	
Santa Rosa	4/17/69	<i>C. incidens</i>	200	10	97	235	
Shrub-Grassland							
San Clemente	1/16/68	<i>C. incidens</i>	27*	1	..	..
		<i>C. inornata</i>	2*	3	..	..
	4/29/69	<i>C. incidens</i>	11	..	5	28	
San Nicolas	3/27/68	<i>C. inornata</i>	11	..	..	..
		<i>C. tarsalis</i>	1	..	..	..
	11/19/68	<i>C. inornata</i>	..	..	1	2
		<i>C. tarsalis</i>	..	..	..	1
	4/8/70	Negative	..	..	..	..
Anacapas							
East Island	12/6/67	<i>C. inornata</i>	120	..	..	..
	1/18/69	<i>C. inornata</i>	..	..	..	1
Middle Island	1/14/69	<i>C. inornata</i>	..	..	..	1
West Island	10/4/68	Negative	..	..	..	..
Southeast Farallon	3/5/69	<i>C. inornata</i>	..	..	..	1

(dead)

* Total number not counted.

that island which has a habitat so suitable for mosquitoes.

The shrubland-grassland habitat islands surveyed include Anacapa, San Nicolas, San Clemente, and South Farallon. Only three species of mosquitoes were found on this group (*C. incidens*, *C. inornata*, and *C. tarsalis*).

H. G. Dyar was probably the first to conduct a mosquito survey on any of the California islands, and in 1907 he reported collecting larvae of *C. peus* ("*C. stigmatosoma*"), *C. quinquefasciatus* ("*C. cubensis*"), and *C. incidens* in rain barrels at Avalon, Santa Catalina Island. In our surveys, we obtained five additional species on that island. One mosquito species (*C. inornata*) was reported from San Clemente Island by Loomis *et al.* (1956) and that species, and two others, were previously known from the island on the basis of specimens in the Los Angeles County museum (personal communication, Charles L. Hogue). The museum specimens represent *C. inornata* collected by D. Meadows in November 1939, and *C. incidens* and *C. peus* collected by Hogue in June 1962. In our surveys, we failed to find *C. peus* on San Clemente—perhaps because no survey was made in late summer or early autumn. Four mosquito species from Santa Cruz Island were reported to us from the museum at the University of California (personal communication, Robert O. Schuster) Agriculture Experiment Station, Davis, California. These are *Culex* (*Neoculex*) spp. *Aedes sierrensis*, *C. incidens*, and *C. inornata* collected in May or June 1967–1969. *Culiseta incidens* and *C. apicalis* also were collected on that island by T. W. Smithson in May 1969 (personal communication, Robert K. Washino). We assume the *Culex* (*Neoculex*) species mentioned above is *C. apicalis*, as collected by Smithson. Five previously unreported mosquito species were found during our surveys on Santa Cruz Island.

Although wild and domestic mammals, humans, resident and migratory birds and some amphibians and reptiles were present

on the islands, only 38 blood meal determinations could be obtained from engorged mosquitoes collected during the study. These were from six *A. p. franciscanus* (three equine and one bovine from Santa Cruz Island and single equine and bovine feedings from Santa Catalina Island) and from 32 *C. incidens* (three equine and three bovine from Santa Cruz Island and 26 bovines from Santa Rosa Island). Thus, all of the engorged mosquitoes had fed either on equine or on bovine hosts, and all were from woodland-grassland habitat islands. The feeding on mammals by these two mosquito species on these islands is similar to the results obtained in the Sacramento Valley of California by Tempelis and Washino (1967). They found that 94 percent of the blood meals taken by *A. p. franciscanus* were from mammals and that *C. incidens* also fed principally on large mammals.

It was concluded that the limited number of mosquitoes inhabiting the islands and the probable infrequency of multiple mosquito blood-feeding cycles involving humans, makes it unlikely under present conditions, that mosquitoes would cause public health problems on these California islands.

During the first survey on east Anacapa Island (December 1967) all 12 of the potential breeding sites that were found were man-made and 6 of these sites produced a total of 120 *C. inornata* larvae. Conversely, during the second survey (January 1969) there was a lack of breeding habitats and the only mosquito that was found was an adult female *C. inornata*. The relatively successful first trip and the unsuccessful second trip might be attributed to the discontinuance of resident personnel on the island shortly after the first survey was made. It is possible that mosquito populations there depended upon the presence of human residence for the establishment of breeding sites. Further evidence in support of this possibility might be drawn from the fact that about 70 percent of all the mosquito breeding

sites found during the study were created by man.

Representatives of the cactus-breeding group of *Culicoides* (*C. cacticolus*, *C. sitiens* and *C. copiosus*) were found on three of the islands surveyed: San Clemente, Santa Cruz and east Anacapa. The prickly pear cactus (*Opuntia* spp.) was found on these islands and probably afforded breeding sites for the midges.

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