MOSQUITO SPECIES AND DENSITIES IN LOUISIANA RICELANDS[1]

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ABSTRACT. By sampling a total of 6 rice fields and 5 fallow fields (approximately 15 sample dates each) during the 1977 rice season, species and population density of mosquitoes that breed in the riceland agroecosystem of Louisiana were determined. Six species were collected from producing rice fields. Three species, *Psorophora columbiae* (Dyar and Knab), *Anopheles crucians* Wiedemann, and *Uranotaenia sapphirina* (Osten-Sacken), were collected in all 3 rice producing regions of the state. Larvae of *Culex erraticus* (Dyar and Knab) were collected from the producing rice fields in the northern and middle producing regions, while larvae of *Cx. salinarius* Coquillett were collected from rice fields in the middle and southern regions of the state. Larvae of *An. quadrimaculatus* Say were collected in the northern and southern regions.

In the southern region *An. crucians, Ur. sapphirina*, and *An. quadrimaculatus* were the predominant species collected during the rice production season. In the middle region of the state, *An. crucians* was the predominant species collected, while in the northern region, *Cx. erraticus* and *An. crucians* predominated. In post harvest fields flooded by rainfall in the southern region, *Cx. salinarius* increased by 99.7% over the mean number/dip collected during the rice producing season.

Floodwater fluctuation caused soil exposure along levees and in areas having higher elevation in the fields thus producing egg deposition habitats for *Ps. columbiae*. Due to this fluctuation, populations of *Ps. columbiae* were produced in all 3 regions during the rice producing season.

Ps. columbiae and *An. crucians* were significantly correlated ($P < 0.05$) and highly significantly correlated ($P < 0.01$), respectively, to both soil and water temperatures. *Cx. erraticus* were significantly ($P < 0.01$) correlated to water salinity. The data indicated that as plant density increased in the fields the larval *An. quadrimaculatus* populations decreased.

Four floodwater mosquito species were collected from the 5 fallow rice fields sampled. Larvae of *Aedes sollicitans* (Walker) were collected from the southern region only, while larvae of *Ps. discolor* (Coquillett) were collected from the middle region only. Larvae of *Ps. ciliata* (Fabricius) and *Ps. columbiae* were collected from fallow rice fields in all rice producing areas of the state.

Eggs of *Ps. columbiae* were the most abundant and adult females showed a significant oviposition preference ($P < 0.01$) for cattle hoofprints while adult female *Ae. sollicitans* showed a significant preference ($P < 0.01$) for flat pans (areas between the levees). The relative abundance of *Ps. columbiae* eggs was significantly correlated ($P < 0.05$) to rainfall ($r = 0.5247$).

In Louisiana there are approximately 476,000 ha of land utilized in the production of rice (both producing and fallow rice fields). Cultural practices used in rice production, physical factors of the land, and use of the adjacent fallow rice fields (with levees still present) for pasturing cattle would place this ecosystem in a high mosquito production category (Davis 1961). Mosquitoes breeding in this agroecosystem pose a nuisance to man and attack his domestic animals. Precipitin tests (Schaefer and Steelman 1969) indicated that cattle serve as a major blood source for 6 mosquito species closely associated with the rice area (76% of all bloodmeals identified). Steelman et al. (1968) reported that the mosquitoes of the Louisiana rice growing area could be important vectors of anaplasmosis to cat-

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tle and cause significant and economically damaging reductions in the average daily gain of cattle (Steelman et al. 1972, 1973, 1976, and 1977). Sudia et al. (1971) showed experimentally that females of *Psorophora columbiae* (Dyar and Knab), one of the major mosquito pests of the rice regions, were capable of transmitting Venezuelan equine encephalitis (VEE) and that this same species was an important vector of VEE in nature.

Numerous authors (Barber et al. 1926, in Louisiana, Horsfall 1937, Schwardt 1939, and Horsfall 1942, in Arkansas, Olson and Newton 1973, in Texas) have published lists of mosquito species collected with light traps in rice growing regions. Meek (1975), Meek and Olson (1976), Meek and Olson (1977) and Olson and Meek (1977) have reported the ovipositional behavior of *Ps. columbiae* in the Texas riceland agroecosystem. Craven and Steelman (1968) reported that the predominant floodwater species (*Ps. columbiae*) breeding in Louisiana producing rice fields upon initial flooding numbered ca. 4.94 to 14.82 million larvae/ha.

This study reports the mosquito species diversity and density in rice fields after permanent irrigation of the fields and the diversity and density of mosquitoes breeding in 3 selected microhabitats of fallow rice fields used as pasturelands for cattle.

MATERIALS AND METHODS

For the purposes of this study, the riceland areas of Louisiana were divided into 3 broad regions based on different geography and rice cultural practices. The southern region consisted of the ricelands located south of the Intracoastal Waterway near Forked Island in Vermilion Parish (92° 15′ N. long., 30° W. lat.). Two producing rice fields and 2 adjacent fallow fields with cattle present were chosen as representative study sites for this region of the state. These fields were immediately adjacent to natural marsh habitats. Rice and cattle production were the only agricultural activities in this region. The middle rice production region consisted of ricelands located north of the Intracoastal Waterway and south of Interstate 10. The land in this region was utilized completely for agricultural production; i.e. rice, cattle, and soybeans. One field and its adjacent fallow field used for pastureland was located in Acadia Parish 1.0 km west of Crowley (92° 20′ N. long., 30° 15′ W. lat.), and a 2nd field and its adjacent fallow field used for pastureland was located in Calcasieu Parish southeast of Lake Charles near Holmwood (93° 5′ N. long., 30° 10′ W. lat.). In the northern region, almost all fallow rice fields were planted in soybeans; however, one permanent pasture with cattle present was located for study adjacent to a rice field. One of the rice fields used to represent this area and the one permanent pasture were located in Ouachita Parish near Bosco (92° N. long., 32° 30′ W. lat.), while the second rice field (without adjacent fallow field) was located approximately 9 km southeast of Monroe near Pine Grove (92° N. long., 32° 30′ W. lat.).

Experimental fields were sampled at 2 week intervals during the 1977 growing season (April through October).

PRODUCING RICE FIELDS. Two flooded pans (areas between the levees where rice is planted) in each of 2 rice fields in each of the 3 regions were designated as experimental sites. Larval sampling was conducted using a standard metal dipper and an accumulator as described by Fleetwood et al. (1978). The accumulator was modified slightly by gluing the wide end of a cutdown plastic funnel to the underside of the WHO transfer apparatus (adult susceptibility kit described by Fleetwood et al. 1978) and then gluing a lid from a 35 ml vial (with a large hole drilled in it) to the narrower end of the plastic funnel. With this modification, smaller 35 ml vials could be used. Three locations in each of the 2 pans studied per field were sampled by taking 5 dips from each location (2 pans/field—3 locations/pan—5 dips/location = 30 dips/field/date).

After the 5 dips were accumulated, the mosquitoes captured were transferred into a 35 ml vial which contained approximately 10 ml of 95% ethyl alcohol. The vial was removed, sealed, labeled, and placed in a larger holding case; and a new vial was placed in position on the accumulator.

Samples from location 1 were taken parallel to and along the margin of a levee. Samples from location 2 were taken parallel to and approximately 1.2 m away from the levee. This collection area was usually located within the border of the heavy rice stand in the pan. Samples from location 3 were taken parallel to and approximately 7.3 m away from the levee. The 3rd location usually corresponded to the conditions in the middle of the field with regard to stand density and water depth.

Various ecological features were recorded at each mosquito sampling location. At the time of sampling, plant height and water depth were recorded at each location. Soil and water temperature were determined for each pan. One 140 ml water sample per pan was obtained and transported to the laboratory to determine pH, salinity, and turbidity. Stand density of each pan studied was estimated by counting the number of plants in a square meter sample after the field had been permanently flooded.

On those sample dates when the soil conditions in the rice fields permitted (Olson and Meek 1977), soil samples were taken and analyzed for floodwater mosquito eggs. Soil samples were taken with a modification of the technique described by Horsfall (1956) and Meek and Olson (1976). Soil samples consisted of 15 × 15 × 2.54 cm of soil and plant material. Samples were chosen at random from 3 microhabitats in the active rice field. Five samples were collected in the 2 study pans in each field, from the lower 3rd of the levee slope, the flat pan, and from tracks made by the guide wheels of rice harvesting equipment (or cattle hoofprints when present). Samples were placed in individual plastic bags, sealed, marked with location data, sample data, and transported to the laboratory for analysis. A modified version of the egg separator described by Horsfall (1956) and Meek and Olson (1976) was used to separate the eggs from the soil. The salt water flotation technique and equipment were the same as described by Horsfall (1956). Eggs were counted and identified to species with keys developed by Ross and Horsfall (1965).

Water from cattle hoofprints was aspirated on sample dates occurring after a rain. In this situation, a total of 30 water samples from hoofprints was collected in each field.

FALLOW FIELDS. Contours in the southern and middle regions were the same in fallow and rice fields (pans and levees) and vegetation consisted of either seeded rye grass or had volunteer vegetation present. Cattle that served as bloodmeal sources for the mosquitoes were present in both the fallow fields and permanent pasture.

In this portion of the study 2 pans (replicates) from each study field were used. Soil samples were taken from fallow fields and permanent pasture, transported to the laboratory, and analyzed for floodwater mosquito eggs when the soil moisture was optimum for egg deposition, as described by Olson and Meek (1977). Procedures used for sampling the fallow fields and the permanent pasture were the same as the soil sampling techniques previously described for rice fields. Five samples from fallow fields from each of 2 pans were chosen at random from within 3 microhabitats (15 samples/pan or 30/field/sample date). The microhabitats were (1) the lower 3rd of the levee slope, (2) the flat pan, and (3) cattle hoofprints. Care was taken to sample only those hoofprints at least 7.62 cm deep and with some vegetation present. Samples were individually bagged as previously described and transported to the laboratory for analysis. Samples were taken at random from 2 microhabitats in the permanent pasture studied in the northern region (10 samples/pan or 20/

field/sample date). From each of 2 replicates, 5 samples were taken from flat ground and 5 samples were taken from cattle hoofprints. Samples were collected from areas having the lower elevations since these areas of the pasture tend to hold water for longer periods and keep the surrounding soil wet which provides egg deposition habitat. The techniques, equipment, and keys used to separate and identify the mosquito eggs were as previously described. Cumulative rainfall data from fallow fields and permanent pasture were collected every 2 weeks so that their effect on mosquito oviposition could be determined.

STATISTICAL ANALYSIS. Statistical analysis of the rice field data was based on a model containing the following sources of variation: region, date/region, field/region, replicate/field/region, and site (microhabitat)/replicate/field/region. There were 18 dates, 3 regions, 2 fields in each region, 2 replicates in each field, 3 sites in each replicate and 5 samples from each site (approximately 3200 samples). A standard transformation ($\sqrt{X + 1}$) was performed on the data. The analysis of variance using the actual and transformed data was obtained. Correlation coefficients were also obtained for all the biological and physical parameters studied in relation to the numbers of each mosquito species present.

The statistical analysis of the fallow field and permanent pasture data was based on a model containing the following sources of variation: region, field/region, replicate/region, and site/replicate/field/region. There were 3 regions, 2 fields in each region, 2 replicates in each field, 3 sites in each replicate, and 5 samples/site (approximately 2500 samples). A nested analysis of variance was conducted, and correlation coefficients were also determined for all mosquito species and rainfall data obtained.

The keys used to identify all mosquito larvae collected, and all mosquito scientific names cited were from Carpenter and LaCasse (1955) and Knight and Stone (1977).

RESULTS

Larvae of 6 species of mosquitoes were collected from producing Louisiana rice fields. Larvae of 3 species, *Ps. columbiae* (Dyar and Knab), *Anopheles crucians* Wiedemann, and *Uranotaenia sapphirina* (Osten-Sacken), were observed in all 3 regions. Larvae of *Culex erraticus* (Dyar and Knab) were collected from producing rice fields in the northern and middle regions of Louisiana, while larvae of *Cx. salinarius* Coquillett were collected in southern and middle regions. Larvae of *An. quadrimaculatus* Say were collected in northern and southern regions but were not observed in the middle region.

The number of mosquito larvae collected in the southern region varied greatly between sample dates (Table 1). No mosquito larvae were collected from March 12–24, when the rice was planted, to May 23. Both rice fields were harvested from July 12–26, and on August 9, sampling continued at 1 field as it was reflooded to produce a 2nd rice crop. Four species, *An. crucians, An. quadrimaculatus, Ps. columbiae,* and *Ur. sapphirina* were collected from the reflooded field, while *Cx. salinarius* were collected from harvest equipment tracks containing rainfall accumulation in the other field. On September 17, both rice fields were dry and on October 1, the rice in the reflooded field was harvested. At this point, sampling in the southern region was discontinued.

The relative abundance of mosquito larvae collected from the middle region is shown in Table 1. From the period of March 17 to April 1, when the rice was planted, to May 16, no mosquitoes were collected. On May 23, 2 species of mosquitoes, *An. crucians* and *Ps. columbiae* were collected from the rice fields sampled in this region. On June 1, *An. crucians* and *Cx. erraticus,* and *Ur. sapphirina* were collected. On July 28, both rice fields in this region were harvested and on August 9, *Ps. columbiae* were collected at 3.76 larvae/dip from rainfall accumulated in harvest equipment tracks in a

Table 1. Mean number of mosquito larvae collected/dip/date in the Louisiana riceland agroecosystem from March 1 to October 1, 1977.

Species	SOUTHERN REGION—Sampling Dates					
	6–15	6–28	7–12	8–9	8–27	9–3
An. crucians	.083±.038[2]	.067±.066	0	.1±.044	0	.150±.089
An, quadrimaculatis	0	0	0	.133±.066	.067±.042	0
Cu. erraticus	0	0	0	0	0	0
Cx. salinarius	.016±.016	0	0	1.067±.431	0	0
Ps. columbiae	.016±.016	0	.067±.042	.033±.033	0	0
Ur. sapphirina	0	0	0	.067±.066	.367±.265	0

	MIDDLE REGION—Sampling Dates							
	5–23	6–1	6–15	6–28	7–12	8–9	9–3	9–17
An. crucians	1.5±1.5	.183±.105	0	0	.067±.042	0	0	.033±.015ph
An. quadrimaculatis	0	0	0	0	0	0	0	0
Cx. erraticus	0	.017±.016	0	.044±.044	0	0	0	.967±.482ph
Cx. salinarius	0	0	0	0	0	0	.367±.163	.433±.21ph
Ps. columbiae	.233±.120	0	.017±.016	0	0	3.76± 1.4ph[3]	12.77± 3.83phh	3.56± 1.28phh
Ur. sapphirina	0	.017±.016	0	0	0	0	0	0

	NORTHERN REGION—Sampling Dates			
	6–14	6–27	7–11	7–25
An. crucians	.033±.022	0.4±.236	.367±.109	0
An. quadrimaculatus	0	0	.017±.016	.033±.022
Cx. erraticus	.133±.071	.133±.133	1.75±0.642	.217±0.102
Cx. salinarius	0	0	0	0
Ps. columbiae	.133±.071	0	0.033±0.022	0
Ur. sapphirina	0	0	0.133±0.071	.05±.05

[1] Total of 6 fields (2 fields/region—2 pans/field—3 locations/pan—5 dips/location—on 18 sampling dates=approximately 3,200 samples. Southern Region planted March 12–24, rice harvested July 12–26; Middle Region planted March 17–April 1, harvested August 1–9; Northern Region planted April 14–28, harvested September 16–October 1.

[2] Standard error of mean.

[3] ph=post harvest, phh=post harvest mosquito production from cattle hoofprints.

Table 2. Correlation between biological and physical characteristics and abundance of mosquitoes for each species breeding in Louisiana rice fields.

Species	Biological		Physical						
	Plant Height	Plant Density	Water Depth	pH	Salt.	Turb.	Soil Temp.	Water Temp.	Distance Levee
Floodwater									
Ps. columbiae	−.24	.034	−.071	−.098	−.071	−.097	.265*	.292*	
Permanent water									
An. crucians	−.036	−.056	−.057	−.145	.015	−.011	.331**	.429**	
An. quadrimaculatus	.046	−.222	−.077	.074	−.102	−.107	.071	.028	
Cx. erraticus	.014	−.139	−.005	−.096	.328**	.088	.179	.213	
Cx. salinarius	.064	.047	−.072	−.157	−.072	−.046	−.024	−.035	
Ur. sapphirina	.054	−.147	−.106	−.034	.023	.084	−.022	−.002	

* Significant at P<0.05.
** Highly significant at P<0.01

post-harvest rice field. On September 3, *Cx. salinarius* were collected from small harvest equipment tracks and *Ps. columbiae* at 12.67 larvae/hoofprint were collected from one of the rice fields where cattle had been allowed to graze. On September 17, *An. crucians, Cx. erraticus, Cx. salinarius,* and *Ps. columbiae* were collected from rainfall accumulated in harvest equipment tracks and *Ps. columbiae* at 3.56 larvae/hoofprint were also collected. On October 1, after both rice fields were dry, sampling was discontinued in this region.

The relative abundance of the mosquito species breeding in the northern rice growing region is also shown in Table 1. From the rice planting period of April 14–28 to June 2, the rice fields remained dry. On June 14, after flooding, *An. crucians, Cx. erraticus,* and *Ps. columbiae* were collected. *An. quadrimaculatus* and *Ur. sapphirina* were also collected from the rice fields in the northern region. The rice fields were dry from August 8 to September 16. The rice was harvested between September 16 and October 1 and after this time the sampling of the northern region was discontinued.

Larvae of *Cx. erraticus* were collected in significantly ($P<0.05$) higher numbers in the northern region than in other parts of the state. In considering the overall mosquito production, it is important to note that the means shown for *Cx. salinarius* and *Cx. erraticus* in both the middle and southern regions were increased somewhat when post-harvest mosquito production was taken into account.

The relative effects of the biological and physical characteristics studied on the abundance of mosquitoes for each species collected are presented in Table 2. Larvae of *Ps. columbiae* and *An. crucians* were significantly correlated ($P<0.05$) to soil temperature and highly significantly correlated ($P<0.01$) to water temperatures. Larvae of *Cx. erraticus* were highly significantly correlated ($P<0.01$) to the salinity of the water. Although not significantly different ($P>0.05$), the data indicated that the number of *An. quadrimaculatus* larvae decreased as plant density increased.

The mean number of floodwater mosquito eggs/habitat/sample collected in fallow Louisiana rice fields is shown in Table 3. Eggs of four flood-water mosquito species were collected from Louisiana fallow fields. *Ps. ciliata* (Fabricius) eggs comprised 1% of the floodwater mosquito eggs collected and were collected in all 3 regions. In the southern region, eggs of *Ae. sollicitans* (Walker) comprised 8% of all eggs collected. Eggs of *Ps. discolor* (Coquillett), were only collected in the middle region and accounted for 1% of all eggs collected. Statistical analysis of the data collected showed no statistically significant effects ($P<0.05$) for regions X species, however, 2 species of mosquitoes were shown to prefer specific microhabits for oviposition. Adults of *Ps. columbiae* preferred cattle hoofprints ($P<0.01$) over levee slopes or flat pans, while *Ae. sollicitans* adults preferred flat pans ($P<0.01$) over levee slopes or hoofprints. Adults of *Ps. ciliata* and *Ps. discolor* showed no statistically significant ($P>0.05$) preference for any oviposition site.

Ps. columbiae was the predominant species breeding in the fallow fields preferring hoofprints as oviposition sites over any other microhabitat sampled. Eggs of *Ps. columbiae* were collected in significantly ($P<0.01$) greater numbers from cattle hoofprints than from levee slopes and the flat pan, although some egg deposition occurred in the two sites. No *Ps. ciliata* eggs were collected from the flat pan areas with the majority of eggs collected from levee slopes. Eggs of *Ps. discolor* were collected only from cattle hoof-

Table 3. Mean number of floodwater mosquito eggs per soil sample within various habitats in fallow rice fields of Louisiana.

Species	Hoofprint	Levee Slope	Flat Pan
	SOUTHERN REGION		
Ps. columbiae	2.243±0.857[1] (32.)[2]**	0.634±0.228 (13.5)	0.93±0.382 (13.0)
Ps. ciliata	0.0	0.019±0.013 (0.5)	0.0
Ps. discolor	0.0	0.0	0.0
Ae. sollicitans	0.09±0.063 (2.5)	0.05±0.029 (2.0)	0.387±0.236 (8.0)**
	MIDDLE REGION		
Ps. columbiae	1.841±0.546 (26.0)**	0.237±0.089 (1.0)	0.060±0.028 (1.5)
Ps. ciliata	0.016±0.007 (1.0)	0.005±0.005 (0.5)	0.0
Ps. discolor	0.005±0.005 (1.0)	0.0	0.0
Ae. sollicitans	0.0	0.0	0.0
	NORTHERN REGION[3]		
Ps. columbiae	0.900±0.308 (10.0)**	0.200±0.107 (5.0)	
Ps. ciliata	0.02±0.02 (1.0)	0.0	
Ps. discolor	0.0	0.0	
Ae. sollicitans	0.0	0.0	

[1] Standard error of mean.
[2] Numbers in parenthesis=maximum number of eggs collected/sample.
[3] Permanent pasture adjacent to rice field.
** Highly significant at $P<0.01$.

prints in the middle rice production region. Significantly more ($P<0.01$) *Ae. sollicitans* eggs were collected from the flat pan sites of the fallow fields than from either cattle hoofprints or levee slopes. Eggs of *Ae. sollicitans* were collected only from fallow fields in the southern region.

The relative abundance of *Ps. columbiae* was significantly correlated ($P<0.05$) to rainfall ($r = 0.5247$). The mean number of eggs collected/hoofprint in the southern region varied from a low of 0.05 on May 16 to a high of 5.50 on August 9. The mean number of eggs collected/hoofprint in the middle region varied from zero on July 12 to a high of 16.9 on September 17. The mean number of eggs collected/hoofprint in the northern region was also variable from none on May 16 to a high on August 9 of 3.0. The data indicated that while the adult *Ps. columbiae* population fluctuated during this study, the majority of the variation occurred between individual hoofprints sampled. The large number of samples processed that contained no eggs caused the regional means to appear low. The egg recovery efficiency utilizing the techniques described was 81% (65 of 80 eggs exposed to the technique in "loaded samples"). A total of 15 possible sample dates was missed because the fallow fields were either too wet or too dry to sample efficiently.

DISCUSSION

A total of 9 mosquito species was observed breeding in the Louisiana riceland agroecosystem. *Ps. columbiae* was the most common species and was collected from all 3 regions and in both producing and fallow rice fields.

The initial appearance of *An. crucians, Ps. columbiae,* and *Cx. erraticus* was influenced to some extent by soil and water temperatures. The temperature interactions observed with these species tend to support the observations of Gunstream (1965) who showed the importance of the pre- and post-flood water temperatures on *Ps. columbiae* egg hatch. The observations of Horsfall and Morris (1952) also support these data, since they showed that in shallow water a particular mean water temperature was important in determining larval abundance in a number of related mosquito species. Another factor limiting mosquito abundance in rice fields was salinity. Larvae of *Cx. erraticus* were significantly correlated with the salinity of the water. Stand density and plant height were other factors which may help to limit populations of mosquitoes in rice fields. Although not statistically significant ($P>0.05$) the data indicated that the number of *An. quadrimaculatus* larvae decreased as plant density increased. Freeborn (1917), Horsfall (1942), Russell and Rao (1942), and Chandler and Highton (1976) have reported the importance of these 2 factors in relation to certain mosquito species.

The most important factor limiting oviposition was rainfall (soil moisture) with respect to mosquito breeding in fallow fields. As reported previously, eggs of *Ps. columbiae* were significantly correlated ($P<0.05$) to rainfall. This tends to support the observations of Horsfall (1963) and Olson and Meek (1977) that moisture content of the soil is important in relation to oviposition by floodwater mosquitoes (*Ps. columbiae* in particular). The preference of *Ps. columbiae* females for hoofprints over levee slopes or flat pans in this study was also important because it confirmed the observations of Meek and Olson (1976, 1977) with respect to ovipositional site preferences.

The observed *Ae. sollicitans* breeding in the southern marshy fallow fields was the 1st reported instance of this mosquito species utilizing ricelands of Louisiana as breeding sites. The limited breeding range of this species can probably be explained by the observations of Knight (1965) and Peterson and Chapman (1970), wherein the salt content of the soil was thought to be important in breeding site selection for both *Ps. columbiae* and *Ae. sollicitans*. The restrictions of *Ae. sollicitans* to the southern riceland may be due to the higher salt content of this marshy soil as compared to other regions.

The data in Table 4 show the mean numbers of larvae/dip/region and the calculated population of mosquito larvae/ha breeding in producing Louisiana rice fields only during the actual cultivation period. In the southern region *An. crucians, Ur. sapphirina*, and *An. quadrimaculatus* were the predominant species produced during the rice production season (4,242, 2,901, and 1,341 larvae/ha, respectively). Floodwater fluctuation caused soil exposure along levees and in areas having higher elevation in the fields which attracted *Ps. columbiae*, and this species averaged 897 larvae/ha over the entire season. *Cx. salinarius* utilized the producing rice field as a breeding area in the southern region averaging 218 larvae/ha, however, they averaged 1.067 (Table 1) larvae/dip (92,957 larvae/ha) in flooded post harvest fields.

In the middle region of the state, *An. crucians* averaged 16,039 larvae/ha during the rice producing season. Greater fluctuation in irrigation water occurred in this region of the state which resulted in larger populations of *Ps. columbiae* larvae (average of 2,213 larvae/ha over the entire season) than in the other 2 regions. *Cx. salinarius* occurred in these producing fields only after the rice had been harvested and rainfall accumulation kept the fields flooded.

In the northern rice producing region, *Cx. erraticus* was the predominant species (an average of 35,432 larvae/ha over the entire season followed by *An. crucians* which averaged 9,871 larvae/ha. Less fluctuation in irrigation water occurred in the northern region and this was substantiated by the comparatively low numbers of *Ps. columbiae* larvae (584 larvae/ha) produced in this region.

Although the use of the "dipping" method of determining the density of mosquito larvae in an aquatic habitat measures only a portion of a $0.09 m^3$ (square foot) surface area, the data obtained can be used to calculate the population density/ha when dipping is conducted at random in various habitats within a field.

When mosquito population density is determined by random sampling in either producing fields or in fallow fields by methodology currently used in applied mosquito control, the resulting population estimates are definitely smaller than those that are usually obtained by mosquito abatement personnel who are carefully trained to sample areas in fields most likely to have mosquitoes present.

Table 4. Comparison of the mean numbers of larvae/dip collected/region in producing Louisiana rice fields during the actual cultivation period only.[1]

	Regions					
Species	South		Middle		North	
Floodwater						
Ps. columbiae	0.0103	(897.2/ha)[a]	0.0254	(2212.8/ha)	0.0067	(583.7/ha)
Permanent						
An. crucians	0.0487	(4242.8/ha)	0.1841	(16038.7/ha)	0.1133	(9870.7/ha)
An quadrimaculatus	0.0154	(1341.6/ha)			0.0100	(871.2/ha)
Cx. erraticus			0.0095[b]	(827.6/ha)	0.4067[d]	(35431.7/ha)
Cx. salinarius	0.0025[c]	(217.8/ha)	[c]			
Ur. sapphirina	0.0333	(2901/ha)	0.0032	(278.8/ha)	0.0367	(3197.3)

[1] Total of 6 fields (2 fields/region—2 pans/field—3 locations/pan—5 dips/location—on 18 sampling dates=approximately 3,200 samples.

[a] Numbers in parenthesis indicate calculated population of mosquito larvae/ha.

[b] *Cx. erraticus* means changed in the middle region when post-harvest production of mosquitoes was taken into account.

[c] *Cx. salinarius* means in the middle and southern regions changed when post-harvest production of mosquitoes was taken into account.

[d] $P < 0.05$.

The latter method often results in the application of insecticides to considerable acreage while in fact only a small percentage of the field area contains mosquitoes.

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