

## NON-HUMAN MALARIA IN MOSQUITOES AND THE ENGLISH SPARROW, *PASSER DOMESTICUS* LINN., IN THE VICINITY OF SALT LAKE CITY, UTAH

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This contribution is part of a continuing investigation into the incidence and distribution of non-human malaria present in northern Utah and the possible correlation of that incidence with mosquito abatement practices. The report includes results obtained by means of blood slides prepared from birds of a sample collection of English sparrows, *Passer domesticus* Linn., and by dissections and examinations of female culicine mosquitoes from the same area from which the birds were collected. Additional species of passerine birds are being investigated, but inasmuch as the results are not conclusive, they were not included. The species of mosquitoes which were examined and included in this report are those most prevalent within this region: namely, *Culex pipiens* group,\* *C. tarsalis* Coq., *Aedes vexans* Meigen, and *A. dorsalis* Meigen.

In the English sparrows examined, all smears containing plasmodia-like sporozoans which were infecting red blood cells were considered as being indicative of the presence of avian malaria. In the species of mosquitoes examined, it is possible that other kinds of sporozoans may also produce stages similar to those of the Plasmodia, hence, all specimens here considered as positive may not necessarily be indicative of malaria. Investigations to determine the kinds of sporozoans present in birds and mosquitoes from this region have been limited, but since no forms other than Plasmodia have been reported, positives have been regarded as Plasmodia in this report.

As far as could be determined no previous investigation of this type has been conducted in the intermountain region. Reeves (1950) made somewhat similar

studies in Kern County, California, and in Yakima, Washington. In these studies he found *Culex tarsalis* to have a natural infection of 16.3 per cent in 1946 and 8.8 per cent in 1947 in Kern County and "less than five per cent" in Yakima, Washington. To our knowledge, no previous field studies have been conducted for species of the genus *Aedes*. Mosquitoes belonging to a number of species of this genus have been experimentally infected with malaria in the laboratory, but no information concerning their natural infectivity is available. *Aedes vexans* which is fairly prevalent in this area, has been experimentally infected (Cantrell and Jordan, 1945). *Aedes dorsalis*, the most abundant pest species within this area, has not been reported, however, either as being naturally or experimentally infected by these sporozoan parasites. The present work is the first to make such a report with reference to *A. dorsalis*.

### METHODS

The mosquitoes were collected alive from humans and domestic animals, by means of New Jersey type light traps, and aspirator tubes. Light traps were made more effective by means of crushed dry ice which was suspended over them in cheesecloth bags, as advocated by Rudolphs (1922). Results obtained indicated increased catches of female mosquitoes where this procedure was followed. The traps were usually operated from sunset until midnight and an average catch of approximately 150 adults was obtained in areas where no abatement of mosquitoes was operative. In comparison, the average catch was seven to ten adults in abated areas. On the few occasions when the traps were allowed to operate from sunset to sunrise, only a slight increase in

\*The *Culex pipiens* group includes *C. pipiens*, *C. erythrorhox* and *C. salinarius*.

the number of mosquitoes was noted, indicating that the majority were trapped during the early evening hours and that continued operation of the trap beyond midnight yielded few additional insects. A cage, constructed of 3/16 inch welding rod, 4 x 4 x 10 inches in size, and covered with bobbinet, was attached to the lower opening of the trap. This cage was removed each morning.

The mosquitoes were kept in quart fruit jars in groups of ten until examined. Each group was anesthetized with tobacco smoke and each insect was then identified to species and individually dissected. The midguts were mounted on glass slides in saline and examined under low and high power for the presence of oocysts. Further examination of the salivary glands was carried out on all individuals possessing oocysts. In addition, the salivary glands of a number of specimens selected at random and not demonstrating oocysts were examined. The dissection technique used was that described by Russell *et al.* (1946).

The sparrows examined were either obtained through the use of U. S. Department of Agriculture type traps made of hardware cloth and baited with wheat, or shot with .22 caliber dust shot. Blood samples were generally taken from the jugular vein in the neck. In cases where this was not possible, blood was obtained from the liver or heart on autopsy. Slides were air dried and fixed for 30 seconds in methyl alcohol and stained with Giemsa stain using standard technique. In order to avoid the transfer of blood cells between slides, they were either stained singly or in small numbers widely separated from each other in the staining jars.

#### DISCUSSION AND RESULTS

Specimens of mosquitoes and birds were collected from the same general areas, and as often as possible from the same localities. In order to provide a basis of comparison, specimens were collected from localities both within and outside of areas in which mosquitoes were abated. The region selected for the study was

divided into three general areas: (1) Salt Lake City proper, under abatement; (2) the area north of the city in Salt Lake and Davis counties; (3) the area south of the city, primarily around the Taylorsville townsite. The latter two areas are largely unabated.

A total of 209 birds and 1072 mosquitoes were examined for malarial parasites. The results are presented in Table 1. The birds examined were seasonally distributed, with some taken at all seasons of the year. Of those birds taken at Salt Lake City, 49 were collected in Liberty Park which is centrally located. All of these birds proved to be uninfected. The remainder of the birds, seven in number, taken from other parts of the city, included one infected bird. The lack of infection in birds taken at Liberty Park may be explained by the fact that they probably do not migrate since ample food and protection are available within the park at the Tracy Aviary, and thus they do not come into contact with infected mosquitoes from other regions. Mosquitoes taken at this location (*Culex tarsalis* Meigen) also proved to be uninfected. The highest incidence of infection in both birds and mosquitoes occurred in the Taylorsville region of south Salt Lake County. Here 26 per cent of the birds and 14.9 per cent of the mosquitoes were found to be infected. Taylorsville is a poultry producing area and is outside of the mosquito abatement districts.

The north Salt Lake County area consists of an agricultural and stock raising area, part of which is in the Salt Lake City Mosquito Abatement District. In addition, the area includes the Farmington Bay Bird Refuge and numerous private duck clubs which provide a large wild bird population. The survey of this area showed 9.3 per cent of 64 birds and 10.9 per cent of 155 mosquitoes to be infected.

*Species of Malaria.* Of the species of malaria present in the birds, one was determined to be *Plasmodium relictum* Grassi and Feletti, and was confirmed by Dr. Carlton M. Herman of the Patuxent Refuge, Laurel, Maryland. The other

species was tentatively identified as *P. cathemerium* Hartman. The latter species frequently occurs in sparrows in this country.

enough to have progressed to the sporozoite stage.

Some of the *Aedes vexans* captured during the late part of the summer were very

TABLE 1.—The Incidence of Plasmodia in the English Sparrow and Plasmodia-Like Organisms in the Mosquitoes of the Salt Lake Region

Location	No. of Mosq. Examined	No. of Mosq. Infected	Per cent of Infection of Mosq.	No. of Birds Examined	No. of Birds Infected	Per cent Infection of Birds
Salt Lake City	96	9	9.35%	56	1	1.78%
North Salt Lake County	155	17	10.9 %	64	6	9.37%
South Salt Lake County	821	122	14.85%	89	23	26.0 %

**Results.** The results of the dissections of mosquitoes are shown in Table 2. Infected salivary glands were not present in every individual which had a positive mid-gut infection, but since the age of the infection is not known this is not significant. Some members of each of the species which had positive mid-gut infection also had infected salivary glands. This indicates that each of the four species found with mid-gut and salivary gland infections are potential vectors of malaria-like organisms. No infected salivary

glands were found in the absence of mid-gut infection. When infected, individuals of this species seemed to be parasitized to a much greater degree than were those of other species.

**Discussion.** Similar studies have been made in the United States, but most of them have been restricted to *Anopheles* species. The only similar studies made in the western United States, with which the authors are familiar are those made by Reeves and Hammon in Kern County, California, and Yakima Valley, Washington. The infection rates for Kern County

TABLE 2.—Summary of Results of Survey (1948 and 1949) \*

Species	No. Examined	No. Infected	Per cent Infection
<i>Culex pipiens</i>	99	18	18.2
<i>Culex tarsalis</i> (1948)	209	19	9.1
<i>Culex tarsalis</i> (1949)	200	35	17.5
<i>Aedes dorsalis</i>	355	48	13.5
<i>Aedes vexans</i>	172	28	16.2

\* A small number of other species was examined with negative findings.

glands were found in the absence of mid-gut infection.

Boyd (1940) found good correlation between the incidence of mid-gut infection and salivary gland infection, but other workers have expressed the opinion that mid-gut infections do not necessarily result in the production of viable sporozoites. The results of this survey could not be cited as evidence for either of the above views because it is not known which of the infections observed were old

compare favorably with those found in *C. tarsalis* from Salt Lake County in 1948 and 1949.

Huff (1931) reported a natural malarial infection rate in *Culex pipiens* of 28.1 per cent in 160 dissections, but no information was given regarding the locality in which the mosquitoes were captured. This infection rate is considerably higher than was found among the same species in Salt Lake County.

As far as could be determined, no

previous study has been made of the natural malarial infection rates among *Aedes* mosquitoes in the United States. Several species of this genus have been infected experimentally in the laboratory, but no information is available regarding their natural incidence of malarial infection. *Aedes vexans* has been reported to have been infected in the laboratory, but as far as can be determined, *Aedes dorsalis* has never been reported either to have been infected experimentally in the laboratory or to possess a natural infectivity.

With such a high natural infection rate present in *Aedes dorsalis*, *A. vexans*, *Culex tarsalis* and the *C. pipiens* group in Salt Lake County, curiosity is aroused as to the sources of these infections. It has been demonstrated that infection exists in the English sparrows. Other birds, as well as reptiles, should be investigated as possible sources of infection. No data are available which show conclusively that the above indicated mosquitoes feed on English sparrows. The only information available giving any knowledge regarding the natural feeding habits of culicine species in the western United States was obtained by Hammon and Reeves (1947) and Hammon *et al.* (1945) in Kern County, California, and by Reeves and Hammon (1944) in Yakima Valley, Washington. By means of precipitin tests, they determined that up to 55 per cent of the *Culex pipiens* and the *C. tarsalis* tested in those areas had fed on certain wild birds. These same studies indicated that most of the *Aedes* examined had fed upon large mammals, i.e., horses, cattle, and sheep.

Pending the outcome of further work on the subject, little of certainty is known regarding the possible sources of infection of these four species of mosquitoes, and much remains to be done before a clear picture of the epidemiology of non-human malaria in this area can be obtained.

The present evidence appears to indicate, however, that lower infectivity exists in both mosquitoes and birds collected from areas in which mosquitoes are abated than from those collected in areas

not so controlled. This is indicated by the 14.85 per cent infectivity in mosquitoes in the south Salt Lake region, which is uncontrolled, as opposed to the 9.35 per cent in the controlled area. This is further indicated by the fact that both mosquitoes and birds taken in the central part of the city were completely negative. The north Salt Lake region, partially under control, showed a medium of 12.8 per cent.

#### SUMMARY

An investigation of the non-human malaria present in adult female mosquitoes and in the English sparrow (*Passer domesticus* Linn.) was carried on in the Salt Lake City region during 1948 and 1949. Four of the most common and important culicine mosquitoes were found to be infected. These were *Culex pipiens* 18.2 per cent, *Culex tarsalis* 9.1 per cent, 1948 and 17.5 per cent in 1949, *Aedes vexans* 16.2 per cent; *A. dorsalis* 13.5 per cent. This report constitutes the first record of infection of *Aedes dorsalis*. Other species investigated proved to be uninfected.

The blood of 209 sparrows was examined for parasites. The sparrows were collected from three general areas, (1) Salt Lake City proper, an area under mosquito abatement, (2) north Salt Lake County, partly under mosquito abatement, and (3) south Salt Lake County, with no abatement. The mosquitoes were collected from the same general localities. Several species of malarial parasites were noted. One was identified as *Plasmodium relicutum*. The other was tentatively identified as *P. cathemerium*. The birds from the Salt Lake region had an infection rate of 1.78 per cent, those from south Salt Lake 26 per cent and from north Salt Lake County 9.37 per cent, indicating that mosquito abatement may be a factor in reducing the incidence of infection in birds and mosquitoes.

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## THE TWENTY-FIFTH YEAR OF MOSQUITO CONTROL IN GREATER WINNIPEG, CANADA. 1951.

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Winnipeg is situated in Manitoba, Canada, midway between the Atlantic and the Pacific coasts, 460 miles north of Minneapolis, at the confluence of the Red and the Assiniboine Rivers. The Greater Winnipeg Anti-Mosquito Campaign controls an area of 250 square miles containing a population of 350,000 people, centering on the City of Winnipeg. The average annual precipitation is 20.47 in., including 5 in. of moisture from snow during the winter months. Our very rapid spring thaw in April results in the formation of many mosquito breeding places. In the warmer part of the summer flying mosquitoes may appear one week after eggs have been covered by rain water.

During the Red River flood of 1950 this campaign used methods and machinery for controlling mosquitoes which helped us considerably in 1951. In 1951 a Lawrence Aero-Mist was added to the two Tifa foggers to round out our heavy insecticide equipment. Where use of these mechanical applicators was not possible,

manual treatment by pressure sprayer was used.

We used 6% DDT water emulsion for water surfaces, and 5% DDT oil solution for fogging, and waste oil applied in certain instances. Water surfaces included ditches, clay pits, sloughs, river banks and marshy land. Fogging encompassed residential districts with special attention to parks, golf courses, community clubs and river banks. This two-way attack against mosquito larvae in the water and the flying adult in the air was again successful in providing effective control against mosquitoes for an 8-mile radius from the center of the city.

Rainfall between April and July was below normal, whereas August rains were 71% above normal. This worked to our advantage in the early part of the season.

Ditch maintenance was carried out by man power and by spraying willows with the power sprayer using 2, 4-D at 0.9 lb. per acre. This gave effective control of willows.

*Pre-season application of DDT.* As an