SURVEY OF ADULT BLACK FLIES (DIPTERA: SIMULIIDAE) FROM TEN SITES IN MISSISSIPPI

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ABSTRACT

Although there are at least 27 reported species of black flies in Mississippi, little is known about which of these are the primary pest species occurring in the state. The resurgence of black flies in Mississippi over the past decade prompted renewed interest in these blood-sucking pests. The purpose of this study was to survey black flies occurring in Mississippi and analyze their seasonality, distribution, and possible relationship of activity versus various meteorological conditions. Black fly adults were collected by hand netting at ten sites around the state for two years. Upon each visit, data was recorded including date, time, temperature, humidity, sky conditions, and wind speed. A total of 350 adult black flies were collected, returned to the lab, and identified. The two main species collected were *Simulium jenningsi* group (248 specimens) and *Simulium meridionale* (98 specimens). Three other species were rarely collected (4 specimens): *S. parmatum* and *S. tribulatum* and *S. johannseni. Simulium jenningsi* was found predominantly from February through July each year, mostly in central, south, and eastern Mississippi, while *S. meridionale* was found from March through July, mostly in the northern Delta region. Analysis of meteorological data indicated that temperature, relative humidity, and sky condition were the main factors affecting black fly flight activity. This study suggests that there are two main pest species of black flies encountered in Mississippi.

Keywords: Black flies; Flight activity; Mississippi; Seasonality; Distribution; Meteorologic factors

INTRODUCTION

One of the first well-documented descriptions of a black fly outbreak in the southern United States occurred in 1859 in Greenville, MS and Clarendon, Arkansas (Webster 1887, 1904) most likely due to the pestiferous black fly species, *Simulium meridionale*. Subsequent sporadic outbreaks occurred in Arkansas, Indiana, Louisiana, Mississippi, and Tennessee from 1874 – 1884, and especially during the spring of 1882, when wild deer were pushed out of swamps by black flies and almost exterminated in Louisiana between the Ouachita and the Mississippi Rivers (Webster 1904). Physicians reportedly verified several human deaths in Louisiana and Arkansas (Webster 1904, Atwood and Meisch 2004). A total of 3,200 head of cattle was lost in a single week in Franklin Parish, Louisiana (Webster 1904).

Beginning in the late 1920s and early 1930s, many reports and complaints were received from Mississippi county extension agents, local veterinarians, physicians, and local farmers about

"gnat" attacks. These pests were reported as *Cnephia pecuarum* and *Simulium meridionale*, which prompted Dr. George Bradley's extensive research on black flies in the South, focusing primarily in the Mississippi Delta (Nations et al. 2016). Black fly problems apparently disappeared from Mississippi until 2008 – 2009, when the Mississippi State Department of Health (MSDH) and the Mississippi State University Extension Service again began receiving complaints from the public about increased human biting incidents and backyard poultry deaths resulting from black flies. Since so little is known about current black fly activity in Mississippi and a lack of statewide expertise on these pests, this study was initiated. In particular, to determine which black fly species are the primary pests in Mississippi, clarify their seasonality and geographic distribution, and attempt to identify meteorological factors affecting their activity.

MATERIALS AND METHODS

Adult black flies were collected from January 1, 2015 through December 31, 2016 by hand netting for 10 minutes in the exact same way each time, from ten locations around Mississippi, each located by a river or creek. Selection of sites was based on historical reports of black fly problems and a survey of Mississippi State University County Extension Agents (Table 1). Collections (n=180) were made twice per month in the peak of black fly activity, February – July, and only once per month other times of the year, August – January. Field notes of various meteorological parameters were made upon each site visit; however, more precise data were subsequently obtained online from the nearest National Weather Service station for each site. For definition of sky condition, categories previously defined by Weather Underground were used (The Weather Company, wunderground.com).

Any black fly specimens collected were placed in 70% ethanol and returned to the lab for identification using published keys (Stone and Snoddy 1969, Adler et al. 2004); subsamples of each species were sent to Dr. Peter Adler (Clemson University) for confirmation. Voucher specimens of each species are deposited in the Mississippi State University Entomological Museum.

Statistical Analysis. Meteorological data were analyzed using the package olsrr (Hebbali 2018) in the R program (R 2019). A stepwise selection method was chosen (both forward and backward), allowing reassessment using partial F tests which emphasized that changing the sites (locations) also changes the importance of meteorological factors affecting black fly activity. The decision threshold to include a given independent variable in each regression was based on $P < 0.05$.

Table 1. Collection sites for the two-year survey.

Collecting Site	County	Nearby body of water
1) Near Lula, MS	Tunica	Mississippi River
2) Near Sledge, MS	Quitman	Coldwater River
3) Near Webb, MS	Tallahatchie	Tallahatchie River
4) Near Money, MS	Leflore	Tallahatchie River
5) Greenville, MS	Washington	Mississippi River
6) Vicksburg, MS	Warren	Mississippi River
7) Jackson, MS	Hinds	Pearl River
8) Near Mendenhall, MS	Simpson	Strong River
9) Near Seminary, MS	Covington	Okatoma Creek
10) Near Shubuta, MS	Clarke	Buckatunna Creek

RESULTS AND DISCUSSION

A total of 350 black flies were collected during the two-year survey comprised of five species (Table 2). The most commonly collected species was *Simulium jenningsi* group (248/350, 71%), followed closely by S. *meridionale* (98/350, 28.0%). Three other species were only rarely collected – *S. parmatum* (2/350, 0.57%), *S. johannseni* (1/350, 0.29%), and *S. tribulatum* (1/350, 0.29%). *Simulium jenningsi* is a group or complex comprised of at least 22 species (Adler et al. 2004). There are perhaps as many as 10 species of the *S. jenningsi* group that cannot be distinguished morphologically which occur (or can be inferred to occur) in Mississippi. Not all of them are human biters, so this complicates defining their "pest" status. *Simulium meridionale* was mostly collected from sites in northwest and central Mississippi from March through July (peak activity April). *Simulium jenningsi* group was collected primarily from sites in central and eastern, and one location in northwest Mississippi, essentially year-round (peak activity May) (Figures 1 and 2). *Simulium parmatum* was only collected in southeast Mississippi during February and March; *S. tribulatum* was only collected in Warren County during 2015; and *S. johannseni* was only collected in Covington County during 2016. Of note is the fact that we collected no specimens of *Cnephia pecuarum*, one of the most famous black fly pests historically found in Mississippi (Nations et al. 2016, Nations et al. 2018). In a larger, more comprehensive survey of black flies in Mississippi, which included museum specimens, we found no *C. pecuarum* reported in the state after the 1930's (Nations et al. 2018).

Table 2. Five species collected during the two-year survey in Mississippi

# Collected	Species
248 specimens	*Simulium jenningsi* group
98 specimens	*Simulium meridionale*
2 specimens	*Simulium parmatum*
1 specimen	*Simulium johannseni*
1 specimen	*Simulium tribulatum*

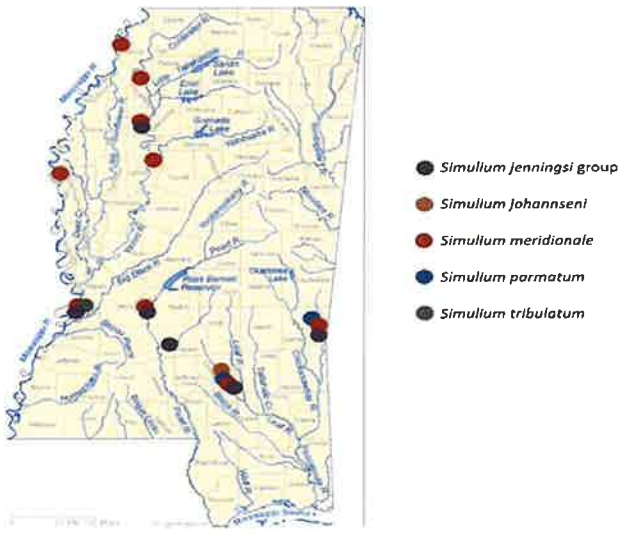

Figure 1. Distribution of species collected at 10 sites in Mississippi.

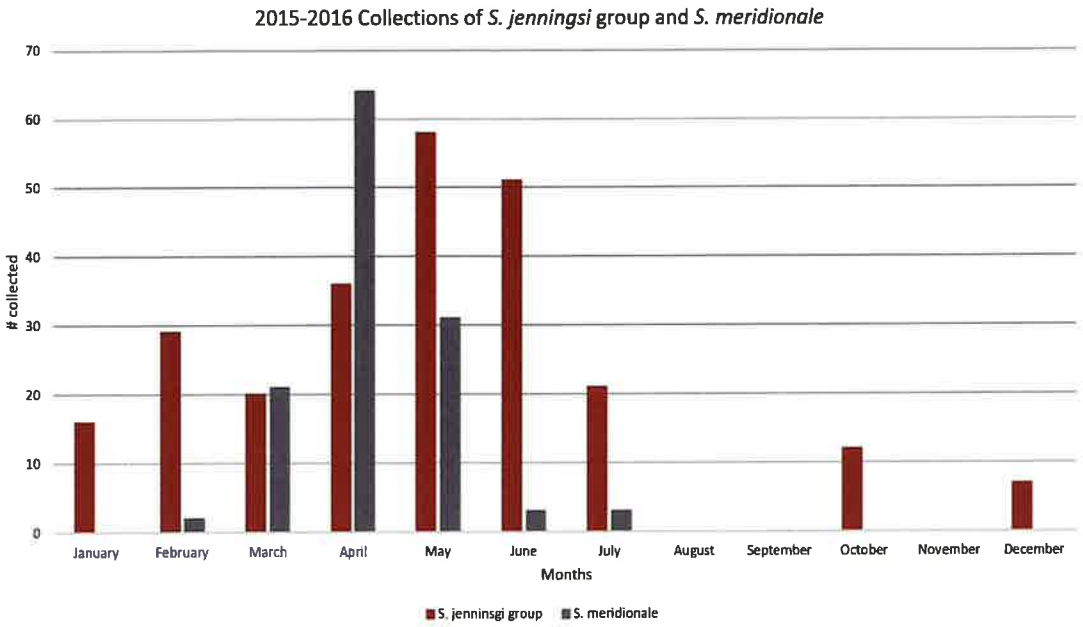

Figure 2. *Simulium jenningsi* group and *Simulium meridionale* seasonality for 2015 – 2016.

Analysis of Meteorological Parameters. A total of 363 trips were made to the ten collection sites, but only 361 could be analyzed (collection site #6 could not be sampled in 2015 and collection site #7 has missing weather data for March 2016). As for meteorological factors affecting black fly activity, previous research has shown that temperature has an effect of black fly emergence and activity (Bradley 1932, Colbo and Porter 1981, Lake and Burger 1983, McCreadie and Colbo 1991, Adler et al. 2017). Therefore, meteorological factors (humidity, sky conditions, temperature, and wind speed) were analyzed to determine which of these, if any, affected black fly activity. In the stepwise multiple regression analysis (Table 3), variables were selected using predictive models, which were able to estimate *S. jenningsi* activity, at least at some locations. Based on *F* values, the predictive model at location 9 was non-significant for *S. jenningsi,* and at locations 1, 3, 5 and 6 for *S. meridionale.* Temperature and relative humidity were the most important factors affecting *S. jenningsi* activity at locations 8 and 10, respectively (both sites located in south-central Mississippi). Selected models for these locations are: $0.4500 + 0.0090\,x$ Temperature [Location 8] and $0.9740 - 0.010\,x$ Relative Humidity [Location 10] (Table 3). As for *S. meridionale* activity, sky condition was the most important meteorological factor at location 2 (a site in the Mississippi Delta), while relative humidity was most important at locations 4 and 7 (north and central Mississippi, respectively). Models for *S. meridionale* in these mentioned locations are: 0.019 + 0.015 x Sky condition [Location 2]; -0.104 + 0.003 x Relative Humidity [Location 4] and -0.094 +0.003 x Relative Humidity [Location 7].

Table 3. Estimated coefficients of the stepwise linear regression analysis of black fly activity (*Simulium jenningsi* and *S. meridionale*) in relation to meteorological factors at different locations in Mississippi.

Species	Location	Variable	*C(p)*	*AIC*	*F* value	*P > F*
S. jenningsi	8	Temperature	0.2250	25.1209	5.592	0.0239
	9	Sky Condition	0.5330	31.9427	1.183	0.2844
	10	Relative Humidity	1.5090	35.8669	7.257	0.0109
S. meridionale	1	Relative Humidity Sky Condition	4.4050 1.1890	-61.7764 -65.3438	3.949	0.0290
	2	Sky Condition	-0.5520	-25.1398	2.468	0.1255
	3	Relative Humidity	0.1850	-20.5395	0.875	0.3560
	4	Relative Humidity	1.4230	-34.4859	5.390	0.0259
	5	Temperature	-0.9630	-24.5856	1.856	0.1821
	6	Temperature	-0.7200	-44.8361	0.725	0.4006
	7	Relative Humidity	1.4230	-34.4859	5.393	0.0260

These findings are not unexpected – most insects are susceptible to desiccation, so humidity is important and, of course, black flies are unable to fly during cold temperatures. The role of sky conditions is not as clear but has been previously reported as a factor in black fly activity (Wolfe and Peterson 1960, Alverson and Noblet 1976, Martinez-de la Puente et al. 2009). This study indicates that there are two commonly encountered species of black flies in Mississippi; they are active primarily during spring and early summer; and temperature, humidity, and (possibly) sky condition are the main factors affecting their activity. Further research using molecular identification techniques is much needed to distinguish the species make-up of *S. jenningsi* group black flies occurring in Mississippi.

CONFLICT OF INTEREST: There is no conflict of interest to declare.

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