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SEASONAL EMERGENCE PATTERNS OF BLACK FLIES (DIPTERA: SIMULIIDAE) IN NORTHWESTERN PENNSYLVANIA[1]

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ABSTRACT

A two-year emergence trap study of black flies at four sites in northwestern Pennsylvania yielded 1963 individuals of nine species. The collections included *Prosimulium mixtum, P. fuscum, Stegopterna mutata, Simulium aureum, S. excisum* (recorded for the first time from Pennsylvania), *S. gouldingi, S.* sp. nr. *innocens, S. vittatum,* and *S. tuberosum.* Species richness for all sites peaked during May. Emergence collections below a sewage plant effluent outfall represented fewer individuals and species than collections above the effluent outfall. Chromosomal analysis of supplementary larval collections revealed the IIIL-1 and IS-7 sibling species of *S. vittatum* and the FG sibling of *S. tuberosum.*

The immature stages of black flies are a near-ubiquitous component of Pennsylvania rivers and streams. In certain areas of the state the adult stage of some species often attains pest status. However, only four papers have dealt directly with the black flies in Pennsylvania (Frost 1949, Goulding and Deonier 1950, Stone and Jamnback 1955, Eckhart and Snetsinger 1969). Accordingly, faunal and biological studies of black flies in the state are far from complete. The present study was, therefore, undertaken to determine the species composition and emergence patterns of adult black flies in northwestern Pennsylvania.

MATERIALS AND METHODS

Four sites in Erie County, Pennsylvania, were used for collections of emerging aquatic insects (Fig. 1). The Sixmile Creek site (42°7′10″ N,79°57′15″ W) at an elevation of 344 m had a substrate with phi values of 42% retained by -5ϕ (coarse rubble) and 32% between -4ϕ and 0ϕ (medium to fine pebbles) (method of determination in Masteller 1980). Fourmile Creek (42°9′35″ N, 80°1′50″ W), with two collection sites, had a phi classification of 37% retained by -5ϕ and 39% between -4ϕ and 0ϕ. Site 1 at an elevation of 287 m was 460 m above a 51,000 gallon per day extended aeration sewage plant effluent outfall. Site 2 at an elevation of 256 m was 90 m below the sewage effluent outfall. Sixmile and Fourmile Creek flow into Lake Erie. Conneauttee Creek (41°51′26″ N, 80°2′22″ W) is a tributary of Big Conneauttee Creek which flows into French Creek, subsequently into the Allegheny River, and eventually into the Ohio River. This site at an elevation of 443 m had phi categories of 57% retained by -5ϕ and 21% between -4ϕ and 0ϕ.

Two trap designs were used. The emergence trap on Sixmile Creek was constructed from Lumite® special screen, a type of shadecloth used in pollination (design in Masteller [1977] and Masteller and Flint [1980a]). Each trap on the remaining sites was a flare parachute (mesh size 0.0025 mm) obtained as surplus from the U.S. Marine Corps.

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All streams were spring fed, first order streams that flowed through climax forests dominated by beech (*Fagus grandifolia*), maple (*Acer* spp.), and hemlock (*Tsuga canadensis*). Emergence of aquatic insects has been studied on Sixmile Creek since 1977, at site 1 on Fourmile Creek since 1980, at site 2 only in 1981, and on Conneauttee Creek since 1980.

Insects were collected from the traps on a regular sequence with mechanical aspirators. Collections were made in the afternoon on alternate days during heavy emergence, and were placed at −5°C before transfer to 70% ethanol for sorting and identification. Water temperatures were recorded at the time collections were made. Conductivity readings were recorded during 1981 with a YSI 33 meter. Weekly analyses of ammonia (as N) were performed by Church Laboratories, Erie, Pennsylvania, on water samples collected from the sewage effluent 90 m above site 2 on Fourmile Creek.

Larval collections from directly below each trap site were preserved in Carnoy's fixative during June 1979, 1981, and early 1982 for all sites except Conneauttee Creek. A voucher collection of adults and larval chromosomes is located in The Frost Entomological Museum of The Pennsylvania State University.

RESULTS AND DISCUSSION

A combined total of 1963 adult black flies of nine species were collected from the four trap sites over a two year period. The species and their totals (males:females) were: *Prosimulium fuscum* Syme and Davies (4:29), *P. mixtum* Syme and Davies (12:94), *Stegopterna mutata* (Malloch) (2:418), *Simulium (Eusimulium) aureum* Fries (3:30), *S. (E.) excisum* Davies, Peterson, and Wood (3:0), *S. (E.) gouldingi* Stone (59:35), *S. (E.)* sp. nr. *innocens* (Shewell) (0:2), *S. (Psilozia) vittatum* Zetterstedt (130:243), and *S. (S.) tuberosum* (Lundström) (372:526).

The present collection includes the first record of *S. excisum* in Pennsylvania and raises the state species total (including sibling species) to 33. Specimens identified as *Simulium* species nr. *innocens* may, in fact, be *S. excisum*. Females of many *S. (Eusimulium)* species are virtually impossible to identify with any certainty. Females predominated at each site for

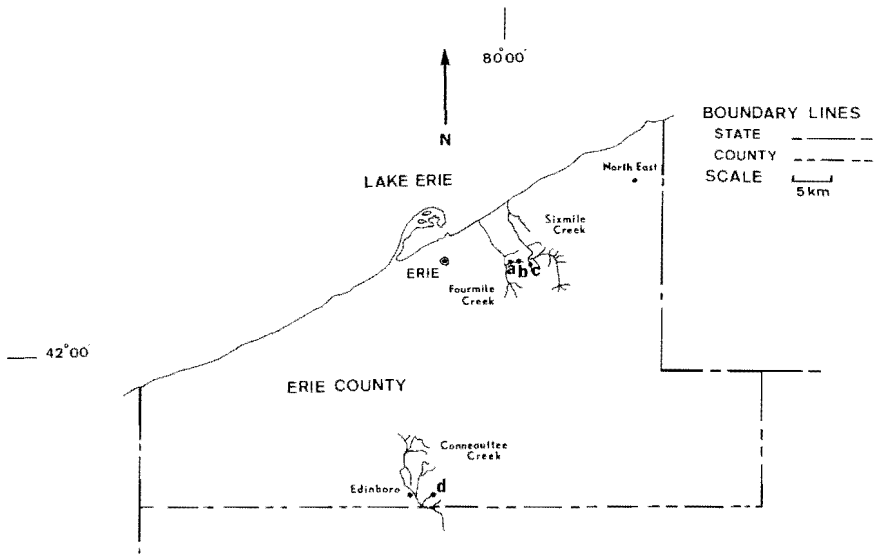

Fig. 1. Map of northwestern Pennsylvania detailing the collection sites: a = Fourmile Creek, site two; b = Fourmile Creek, site one; c = Sixmile Creek; d = Conneauttee Creek.

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all species except the ornithophilic *S. gouldingi* and *S. excisum*, although only three specimens of the latter were collected. The low numbers of male *St. mutata* collected in this study (two from Sixmile Creek) are indicative of predominantly parthenogenetic triploid populations (Basrur and Rothfels 1959).

Emergence periods of black flies and maximum-minimum water temperatures are shown for the four trap sites (Figs. 2–5). Week numbers given in Figures 2–7 follow the system of Taylor and French (1972) as reported in Masteller and Flint (1980b) where week number 1 corresponds to January 1–January 7. Site 1 on Fourmile Creek (average conductivity = 303.4 μmhos/cm, range = 170–420 μmhos/cm, Fig. 2) and Sixmile Creek (average conductivity = 221.1 μmhos/cm, range = 80–420 μmhos/cm, Fig. 3) were very similar in species composition with a peak for species richness in May. However, the polyvoltine species (*S. aureum*, *S. vittatum*, and *S. tuberosum*) at site 1 on Fourmile Creek emerged in large numbers into October and November of both years. Emergence of *S. vittatum* (Fig. 6) and *S. tuberosum* (Fig. 7) at site 1 on Fourmile Creek typically indicated three to four population peaks annually.

The polyvoltine species at Sixmile Creek showed a shortened emergence with only nine individuals (all *S. tuberosum*) emerging later than mid-July in 1981. Reasons for a depauperate black fly fauna at Sixmile Creek in 1980 (seven individuals collected) are unknown,

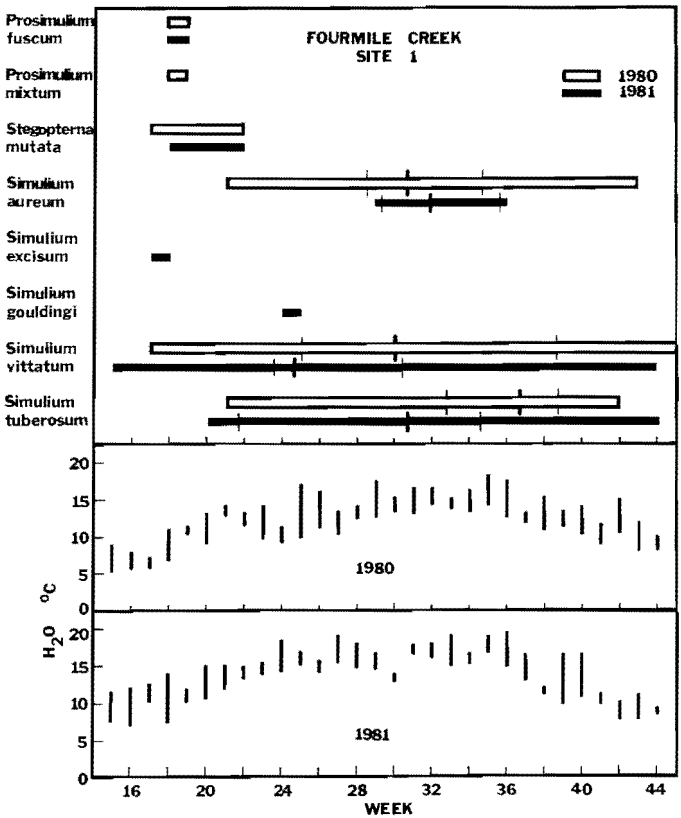

Fig. 2. Emergence periods of black flies with respect to water temperature at site 1 on Fourmile Creek, Erie County, PA during 1980–1981. Heavy vertical marks on the emergence bars indicate 50% emergence; light vertical marks indicate 25% and 75% emergence, respectively.

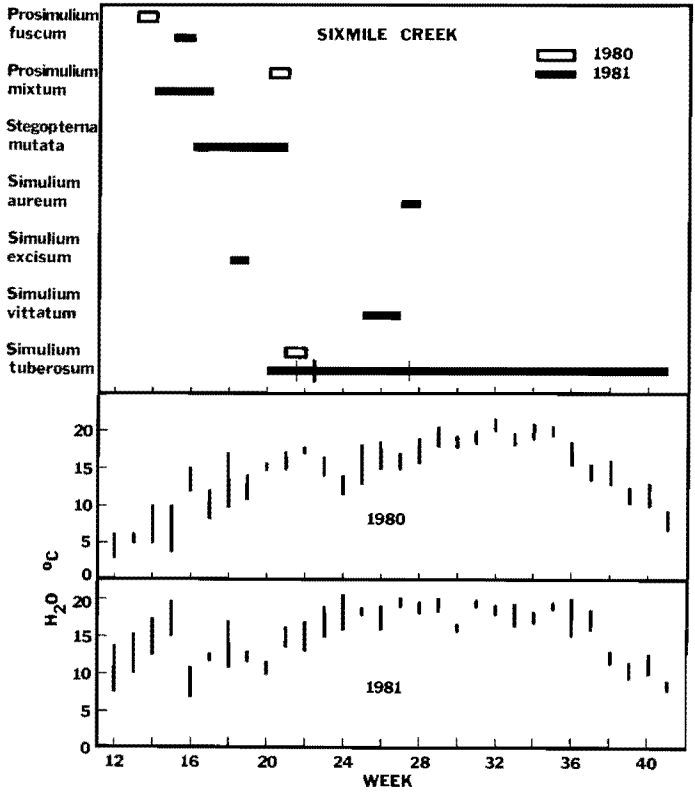

Fig. 3. Emergence periods of black flies with respect to water temperature at Sixmile Creek, Erie County, PA during 1980–1981.

although concomitant collections of Trichoptera and Plecoptera were also lower than usual. Sixmile Creek warmed more rapidly and subsequently maintained a higher temperature during 1980 and 1981 than did all other sites. The early warming was probably responsible for earlier emergences of the *Prosimulium* spp.

Site 2 on Fourmile Creek (average conductivity = 289.2 μmhos/cm, range = 130–480 μmhos/cm, Fig. 4) was poorer in individual and species numbers in 1981, presumably because of its location below a sewage treatment facility. Levels of ammonia at the effluent outfall 90 m above this site sometimes exceeded 30.0 mg/litre while coliform counts reached 40,000 per 100 ml. However, ammonia and coliform levels at the actual trap site were undoubtedly lower, particularly in spring when the water level was higher. Ammonia concentrations of 0.6 mg/litre can cause 100% mortality among laboratory-reared black fly larvae (Grunewald 1972). From mid-June to September, the ammonia concentration at the effluent outfall averaged 1.0 mg/litre, during which time 82.3% of the black flies at site 2 emerged.

Back and Harper (1979) divided black flies into two groups, based on emergence studies in the Laurentides of Quebec: (1) a univoltine group that begins to emerge in mid-May and includes the *Prosimulium* spp. and *St. mutata*, and (2) a polyvoltine group that begins to emerge the third week of May (earlier for *S. vittatum*) and includes *S. aureum*, *S. vittatum*, and *S. tuberosum*. These groupings are applicable to data of the present study which were

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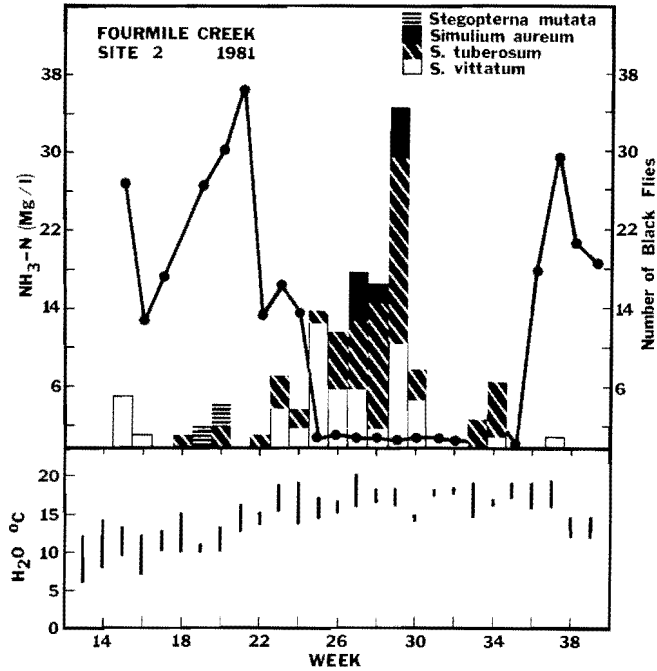

Fig. 4. Emergence patterns of black flies with respect to water temperature at site 2 on Fourmile Creek, Erie County, PA during 1981. Ammonia was measured at a sewage outfall 90 m above the site.

collected 4° farther south and about 5° farther west. However, emergence of the univoltine group plus *S. vittatum* began over a month earlier than in the Laurentides and in Davies' (1950) ten-year study in Algonquin Park, Ontario.

A decrease in latitude, therefore, tends to generate a longer flight period, particularly for the polyvoltine species. Water temperature is a major determinant of such trends since it influences egg hatching and larval development rates (Ross and Merritt 1978). Inception of emergence in the present study occurred shortly after water temperatures reached 10°C. Fall emergence of *S. vittatum* and *S. tuberosum* also terminated when water temperatures consistently registered below 10°C (Fig. 2). The latest emergence dates for these species in the Laurentides and in Algonquin Park were at least six weeks earlier. Members of the univoltine group at all four trap sites completed their emergence before maximum water temperatures consistently exceeded 15°C.

Only species of the univoltine group, with the exception of one female *S. tuberosum*, were collected from Conneauttee Creek (Fig. 5) which ceased to flow in mid-July 1980 and early June 1981. *St. mutata* was the most abundant species (395 individuals) at this site in both years. *S. gouldingi* was second in abundance (91 individuals) during 1980, but exhibited a very restricted period of emergence. In 1981 only three males of *S. gouldingi* emerged before the flow terminated. Although *S. gouldingi* is reported to be univoltine (Stone and Jamnback 1955, Davies et al. 1962) we have found adults into late September in central Pennsylvania.

Species of the polyvoltine group such as *S. vittatum* may be precluded from colonizing intermittent streams, in part, because their eggs are unable to withstand dessication (Wu 1931). However, polyvoltine species are good colonizers of stream areas such as site 2 on Fourmile Creek that are alternately polluted and unpolluted over time.

S. aureum, *S. vittatum*, and *S. tuberosum* are actually species complexes of, respectively, 10 (K. H. Rothfels, pers. comm.), two (Rothfels 1981), and nine (Mason 1982) morphologi-

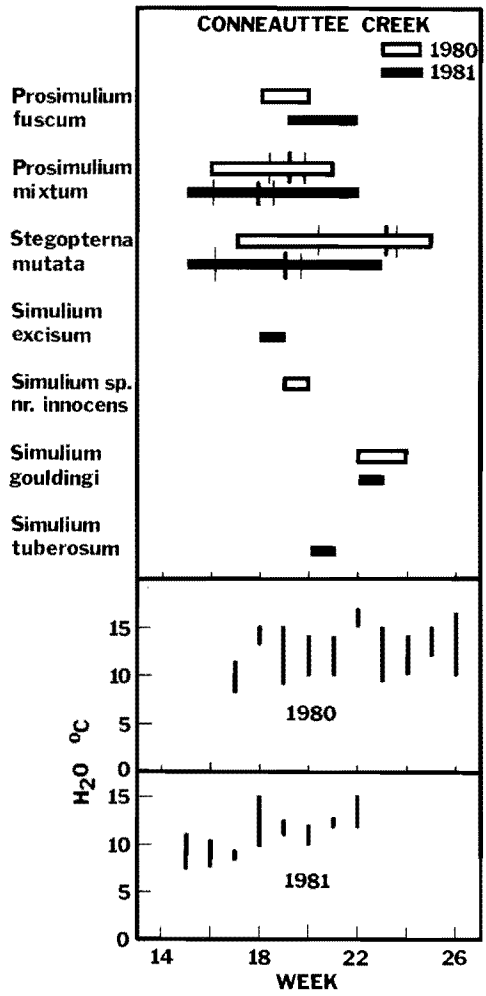

Fig. 5. Emergence periods of black flies with respect to water temperature at Conneauttee Creek, Erie County, PA during 1980–1981.

cally inseparable species (sibling species). The IS-7 sibling of *S. vittatum* was collected as larvae in mid-June 1981 and 10 April 1982 from Fourmile Creek (site 1) and the IIIL-1 sibling was collected in mid-June 1981 from Sixmile Creek. Both the IIIL-1 and IS-7 siblings were collected from Fourmile Creek (site 1) throughout June 1979. Larvae of the FG sibling of *S. tuberosum* were collected in mid-June 1981 from Fourmile Creek (sites 1 and 2) and Sixmile Creek. Larvae of *S. aureum* were not examined. Due to the presence of more than one sibling species, emergence patterns and number of generations for some species should be interpreted cautiously.

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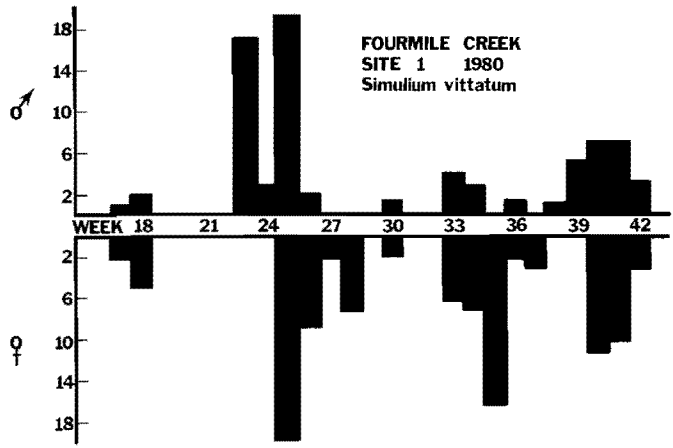

Fig. 6. Emergence patterns for males and females of *Simulium vittatum* at Site 1 on Fourmile Creek, Erie County, PA during 1980.

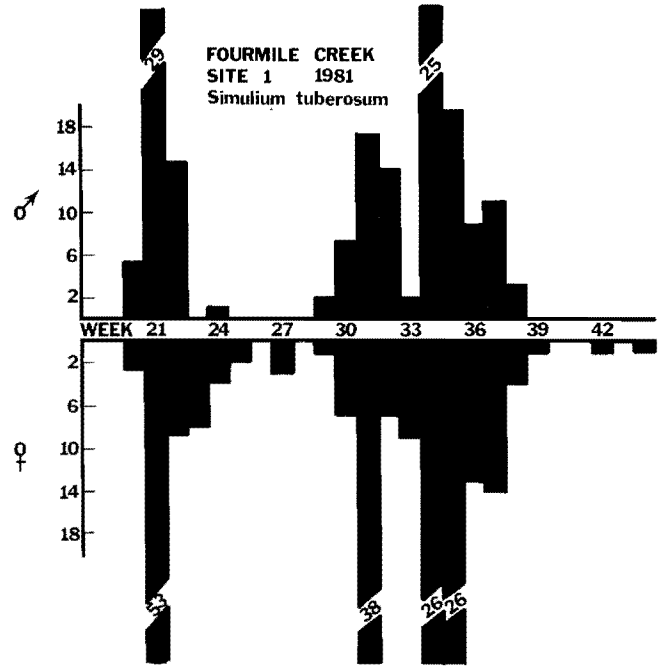

Fig. 7. Emergence patterns for males and females of *Simulium tuberosum* at Site 1 on Fourmile Creek, Erie County, PA during 1981.

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