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Comparison of Tropical and Temperate Emergence Phenology of Aquatic Insects from Puerto Rico and Pennsylvania

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ABSTRACT: Emergence patterns of aquatic insects from Quebrada Prieta in the Luquillo Mountains of Puerto Rico were compared with those from Fourmile Creek near Lake Erie in Pennsylvania. The tropical site, Quebrada Prieta, El Verde, Puerto Rico was dominated by Ephemeroptera, while the temperate site, Fourmile Creek, Erie County, Pennsylvania was dominated by Chironomidae (Diptera). Seasonality is quite apparent in the temperate site, and there is a degree of seasonality in some groups from the tropical site (e.g., Trichoptera and Psychodidae).

Emergence traps for adult aquatic insects have been used since the late 1970's to monitor insect populations in northwest Pennsylvania. In 1989, preliminary sampling was initiated in the Luquillo Experimental Forest of northeast Puerto Rico. Fifty-one weeks of collections were obtained from the Quebrada Prieta from February 1990 through January 1991, and the trap has been in almost continuous operation since that time. The design and size of trap placed in Puerto Rico is the same as has been used the past few years in Erie, Pennsylvania (Masteller and Flint, 1980). Collections were made as close to three days a week as possible throughout the year at both sites.

Emergence patterns of Trichoptera (Masteller and Flint, 1983), Plecoptera (Masteller, 1983), Simuliidae (Adler et al., 1982), Psychodidae (Masteller and Wagner, 1984; Wagner and Masteller, 1992), and Ephemeroptera (Burian and Masteller, in prep.), as well as papers presented on Tipulidae, Ceratopogonidae, and Sciaridae from the traps located in Pennsylvania have been described.

The objective of this paper is to compare the emergence patterns of the major groups of aquatic insects at these two locations and offer an initial comparison of species composition at the tropical and temperate sites.

Methods

Descriptions of the tropical site are provided in the introductory paper in this series (Masteller and Buzby, 1993). The temperate site description is provided in Adler et al. (1982). Averages of precipitation for the collection period are shown in Fig. 1. Leaf fall data for Puerto Rico are shown in the first paper of this series (Masteller and Buzby, 1993). Temperate leaf fall is described in Merritt et al. (1984) and Petersen and Cummins (1974). The major aquatic groups are compared by percentage with pie graphs (Fig. 2). Two traps were located on Fourmile Creek in Erie, Pennsylvania, and referred to as site 1 and 2.

Results

Currently many comprehensive studies in temperate areas compare the Ephemeroptera, Plecoptera, and Trichoptera (EPT ratios). During 1990 (Fig. 3), there was typical abundance of Ephemeroptera, Trichoptera, and Plecoptera at the temperate stream. One of the big differences in the Puerto Rican fauna is the lack

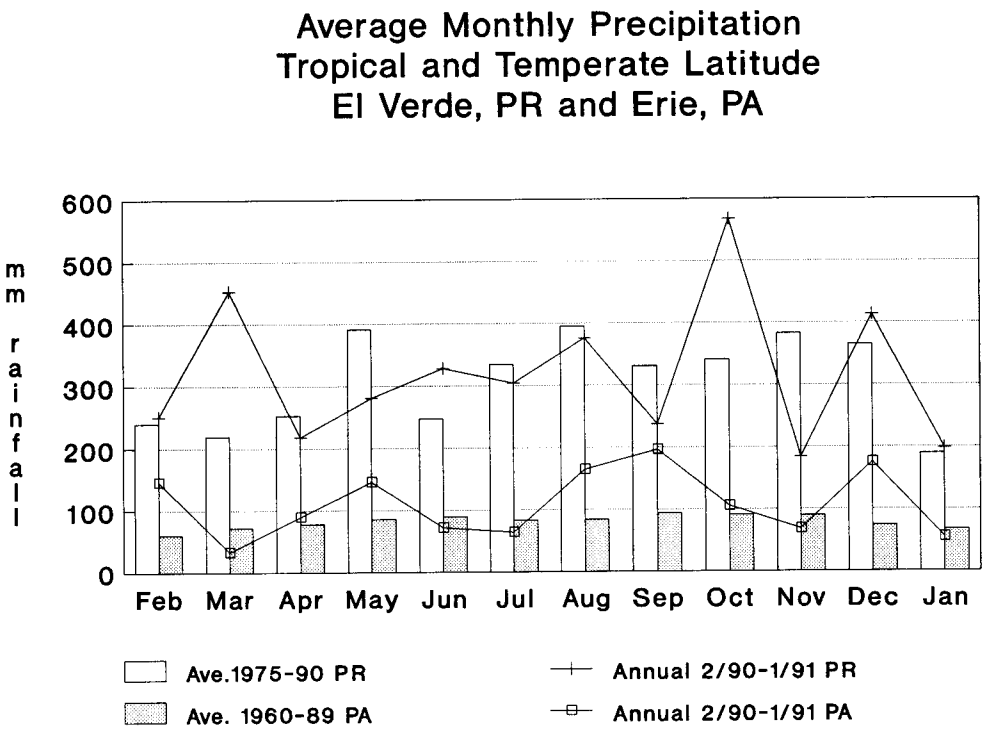

Fig. 1. Average monthly precipitation at El Verde, Puerto Rico and Erie, Pennsylvania: 15 and 30 year averages and monthly averages for the research period.

of Plecoptera from Quebrada Prieta. Plecoptera made up 6% of the fauna at site 1 in Fourmile Creek (Fig. 3). Comparison of Ephemeroptera and Trichoptera from the tropical site (Quebrada Prieta, El Verde) is made in Fig. 4. Collections of 3324 specimens of Ephemeroptera at Quebrada Prieta included 7 species of which one was a new species. Ephemeroptera at Fourmile Creek also included 7 species from 679 individuals. Collections of 2561 specimens of Trichoptera at Quebrada Prieta included 15 species of which 7 are new species. Trichoptera at Fourmile Creek consisted of 20 species from 244 individuals. Plecoptera were abundant at Fourmile Creek, with 1181 specimens belonging to 10 species. The Ephemeroptera and Trichoptera show a uniform emergence in the tropics but distinct seasonal patterns in the temperate latitudes.

At Quebrada Prieta, the Chironomidae were represented by 2451 specimens belonging to 30 taxa. At Fourmile Creek, 16,171 specimens were collected, with a tentative designation of 50 species. Site 1 had a very large emergence of Chironomidae (Diptera) due to a very significant population of *Diamesa cheimatophila* which emerged in the winter months. The Ceratopogonidae, Empididae, Psychodidae, Simuliidae, and Dixidae gave the following annual abundances: Fourmile Creek—57, 161, 118, 85, and 11 (Fig. 5A); Quebrada Prieta—1048, 791, 313, 85, and 28 (Fig. 5B). The species in each group have been determined only for the Empididae (2 tropical and 7 temperate), Psychodidae (8 tropical and 15 temperate) and Simuliidae (1 tropical and 4 temperate). Collections of Tipulidae were 134 specimens with 23 species at Quebrada Prieta and 193 specimens

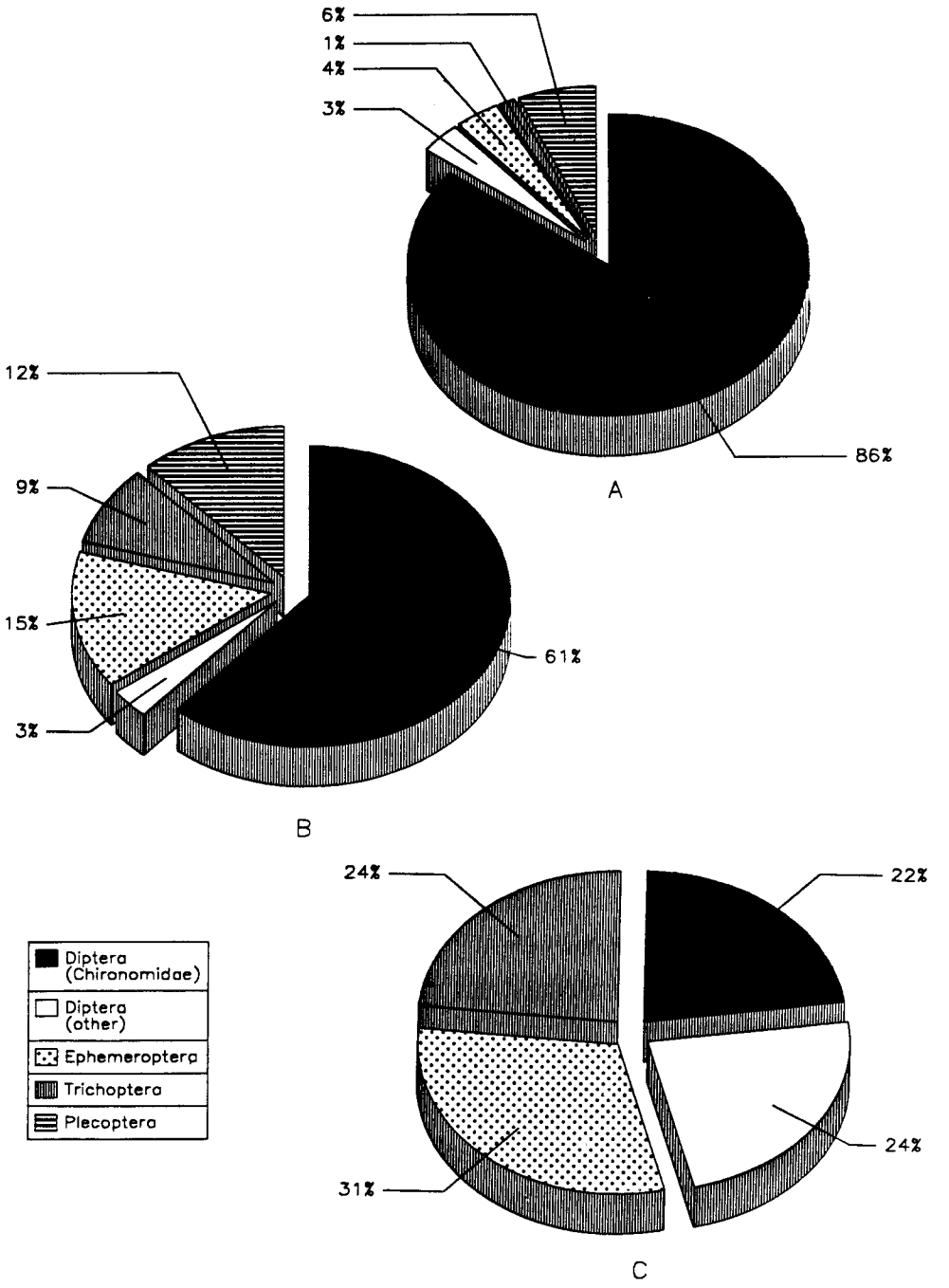

Fig. 2. 2A. Abundance of the major aquatic insect groups collected in an emergence trap at Site 1, Fourmile Creek, Erie, PA, designated by percent of adults. 2B. Abundance of the major aquatic insect groups collected in an emergence trap at Site 2, Fourmile Creek, Erie, PA, designated by percent of adults. 2C. Abundance of the major aquatic insect groups collected in an emergence trap at the Quebrada Prieta, PR, designated by percent of adults.

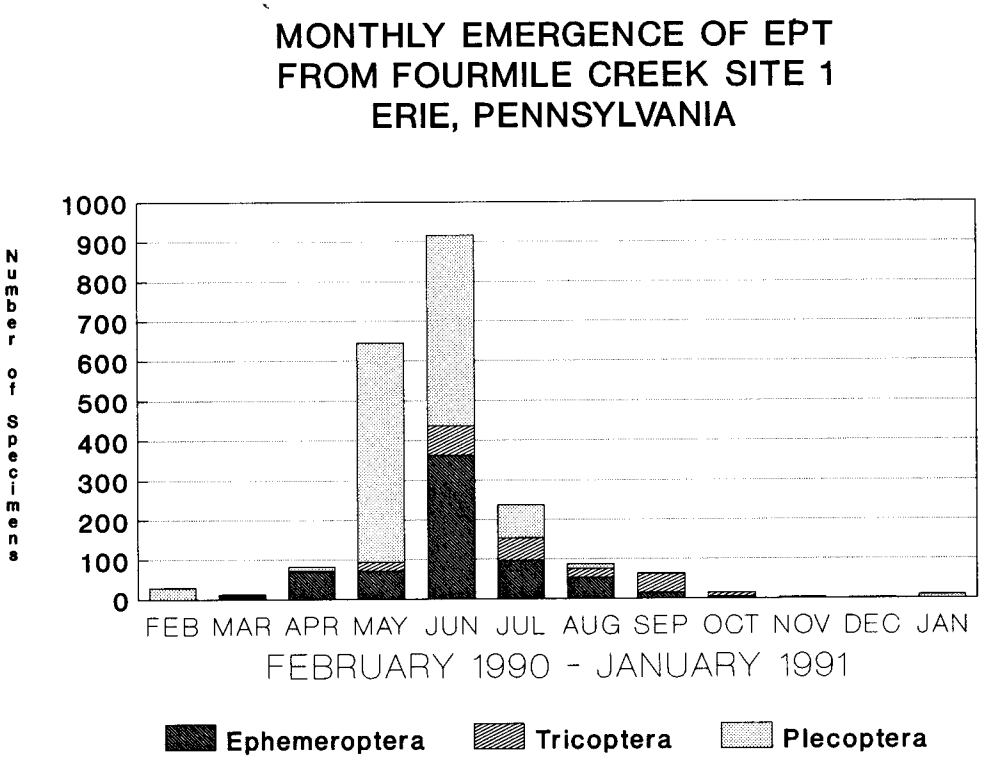

Fig. 3. Monthly emergence of Ephemeroptera, Plecoptera, and Trichoptera from Site 1, Fourmile Creek, Erie, PA.

and approximately 25 species at Fourmile Creek. Tentatively, for the Dixidae, there may be only one species at the tropical site and three species at the temperate site.

The Chironomidae show some uniformity of emergence in the tropics and at temperate latitudes. The Empididae show a seasonal emergence in the temperate habitat but emerged somewhat uniformly in the tropics. The Psychodidae were most common during the summer months in the temperate site but were found in all months in the tropics. Populations of psychodids were reduced from May–July in the tropics. A similar trend is apparent for the Ceratopogonidae at the temperate latitude with reduction in numbers in May and June in the tropics. The Tipulidae were seasonal at the temperate site and there is some seasonality at the tropical site.

Comparing all fauna, the tropical site is dominated by Ephemeroptera while the temperate sites were dominated by Chironomidae. The Ephemeroptera comprised only 4% and 15% of the aquatic fauna at the two temperate sites. Chironomidae were the dominate faunal component of the temperate site.

Discussion

From this study it is apparent that certain trophic niches of temperate environments are being filled by different organisms in the tropics. Many of the insects collected as adults are extremely small in the tropics as compared with the tem-

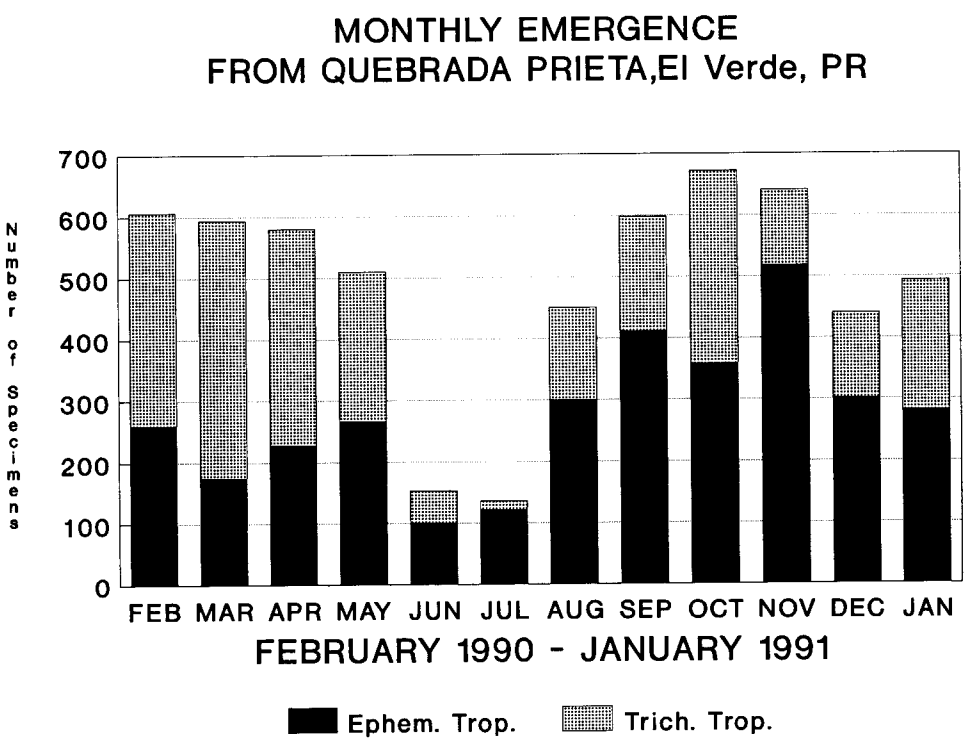

Fig. 4. Monthly emergence of Ephemeroptera and Trichoptera from Quebrada Prieta, PR.

perate-latitude insects. The dominance of the Ephemeroptera should be substantiated by further sampling. The numbers may have been increased to some extent by the effects of Hurricane Hugo, which opened the canopy and provided more food for the grazing community. As the canopy returns to its previous condition, their numbers may decline. Further data collection may resolve this issue, but it is apparent that Ephemeroptera are a dominant group at Quebrada Prieta. In the Diptera, the Ceratopogonidae are extremely abundant at the Quebrada Prieta habitat. Many of these could be filling the niche of predators. The Trichoptera were also much more abundant in Quebrada Prieta than in the temperate site. But the number of species was less in the tropics. The most abundant caddisfly was the small (adult length 1–3 mm) *Cariboptila orophila,* which probably functions as a scraper. *Diplectrona modesta* (adult length 12–14 mm), the most abundant species of Trichoptera at the temperate site, functions as a collector-filterer.

The production in numbers per square meter per day showed the continual presence of adult insects in the tropical environment but does give some indication of seasonality in the various groups. Illies (1975) found considerable annual fluctuation in the production of aquatic insects collected by an emergence trap in a temperate latitude situation in Germany. In his studies he described the "Great Four," caddisflies, mayflies, stoneflies, and chironomid midges as comprising 90% of the total biomass. The situation was similar at the Erie, Pennsylvania site. If we identify a "Big Four" for the tropical site in Puerto Rico, they would be mayflies, caddisflies, biting midges (certaopogonids), and dance flies (empidids).

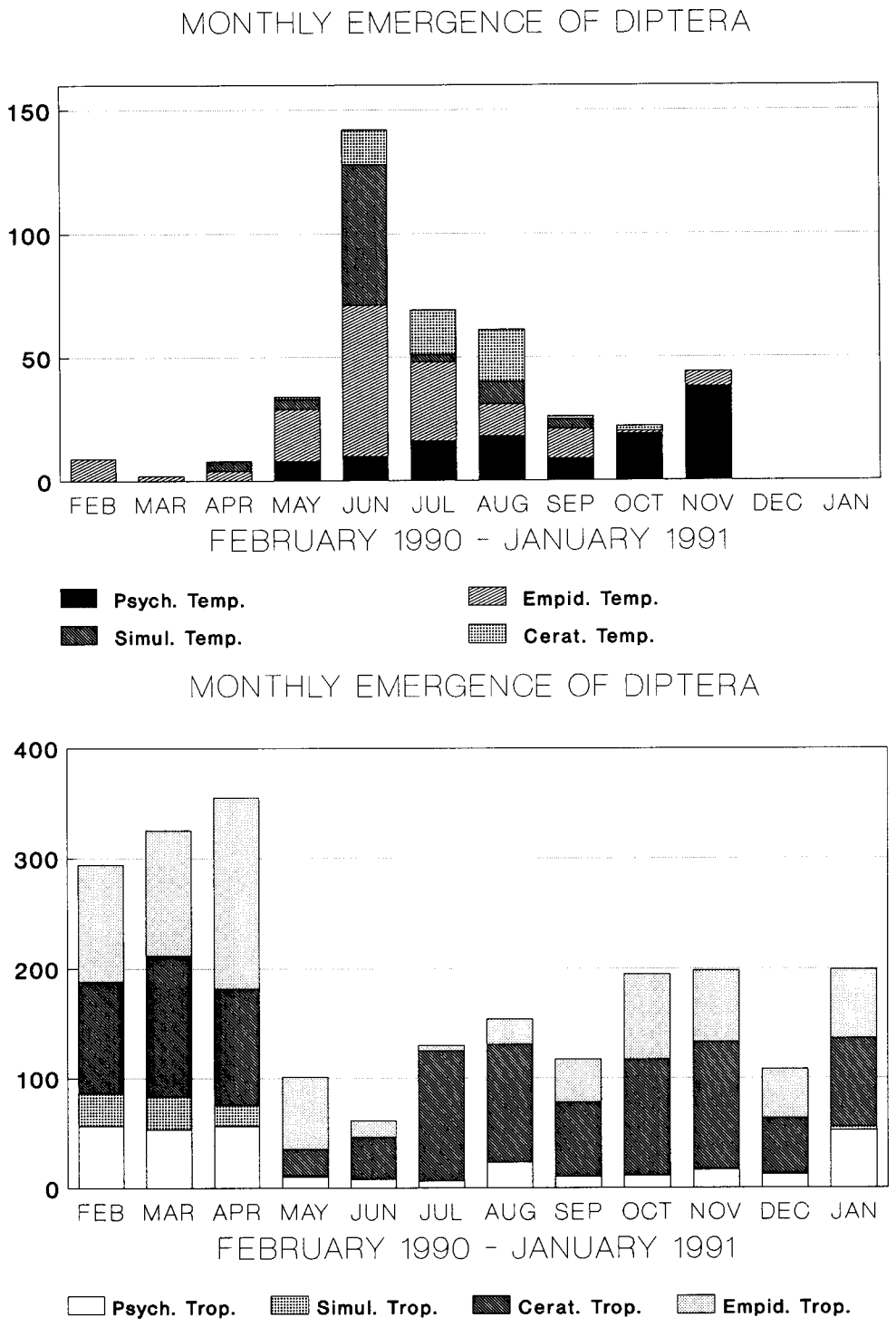

Fig. 5. 5A. Monthly emergence at Fourmile Creek, Site 1 (Erie, PA) of other common Diptera. 5B. Monthly emergence at Quebrada Prieta (El Verde, Puerto Rico) of other common Diptera.

These comprise 93% of the fauna. Illies (1975) concluded that the abundance of Trichoptera and Plecoptera was controlled by precipitation. He also suggested that predation could be responsible for annual variations.

Wolda (1978) stated that tropical insect populations should be close to carrying capacity of the environment, K-selected. The greater climatic stability and predictability would produce smaller fluctuations in abundance. Temperate populations would be kept below environmental carrying capacity by repeated climatic catastrophes, thereby being composed of R-selected taxa. He stated that insects from areas with low and unpredictable rainfall tend to have larger annual variability. Our data tend to support Wolda's conclusions. Additional years of data collection in the tropics should substantiate this conclusion, but it must be noted that the Quebrada Prieta is part of an insular habitat.

McElravy et al. (1982) found that Trichoptera from Panama collected by light traps over a 32-month period had on the average longer active seasons and less sharp seasonal peaks of abundance than Trichoptera from temperate habitats. They reported some indication of temporal isolation of closely related species which, they hypothesized, was to minimize interspecific interaction. They also stated that populations of tropical insects were not more stable than their temperate counterparts. They reported that adult Trichoptera were generally seasonal and that environmental cues to synchronize life cycles could be small annual changes in temperature, photoperiod, light intensity (due to weather and cloud patterns), stream discharge, or quantity of allochthonous input.

Emergence at temperate latitudes is regulated by several factors, one of the most dominant being temperature, which probably regulates many species. Within aquatic insect groups, certain species had emergence patterns closely correlated with photoperiod, while others tended to emerge immediately prior to barometric pressure changes, especially barometric depressions. The first two of these variables do not appear to be factors in the tropics.

We have not determined which environmental factors could be controlling emergence in Puerto Rico, though additional years of data may provide some answers. Lunar cycles have been suggested by Pescador et al. (1993), and Flint et al. (1993) has indicated precipitation could be a trigger for emergence.

Literature Cited

Adler, P., B. Travis, K. C. Kim, and E. C. Masteller. 1982. Seasonal emergence patterns of black flies (Diptera: Simuliidae) in northwest Pennsylvania. Great Lakes Entomologist. 15:253–260.

Flint, O. S. Jr., and E. C. Masteller. 1993. Emergence Composition and Phenology of Trichoptera from a Tropical Rainforest Stream at El Verde, Puerto Rico. J. Kansas Entomol. Soc. 66(2): 140–150.

Illies, J. 1975. A new attempt to estimate production in running waters (Schlitz studies on productivity, No. 12). Verh. Internat. Verein. Limnol. 19:1705–1711.

McElravy, E. P., H. Wolda, and V. H. Resh. 1982. Seasonality and annual variability of caddisfly adults (Trichoptera) in a "non-seasonal" tropical environment. Arch. Hydrobiol. 94(3):302–317.

Masteller, E. C. 1983. Emergence phenology of Plecoptera from Sixmile Creek, Erie County, Pennsylvania, U.S.A. Aquatic Insects 5:1–8.

Masteller, E. C., and K. M. Buzby. 1993. Composition and temporal abundance of aquatic insect emergence from a tropical rainforest stream, Quebrada Prieta, at El Verde, Puerto Rico. Introdution. J. Kansas Entomol. Soc. 66(2):133–139.

Masteller, E. C., and O. S. Flint, Jr. 1980. Caddisfly (Trichoptera) emergence patterns from two streams of the Allegheny National Forest area of Pennsylvania. Melsheimer Entolmol. Ser. No. 29:12–22.

Masteller, E. C., and O. S. Flint, Jr. 1983. Trichoptera emergence patterns from a small stream in northwestern Pennsylvania impacted by sewage effluent. Pp. 225–233 *In* Proceedings of the Fourth International Symposium on Trichoptera. Clemson University.

Masteller, E. C., and R. Wagner. 1984. The impact of sewage effluent on the occurrence of Psychodidae (Diptera) in a stream. Freshwater Invertebr. Biol. 3(2):98–104.

Merritt, R. W., K. W. Cummins, and T. M. Burton. 1984. The role of aquatic insects in the processing and cycling of nutrients. Pp. 134–163 *In* V. H. Resh and D. M. Rosenberg (Eds.), The Ecology of Aquatic Insects. Praeger Publ. New York, NY.

Pescador, M. L., E. C. Masteller, and K. M. Buzby. 1993. Composition and Phenology of Ephemeroptera from a tropical rainforest stream at El Verde, Puerto Rico. J. Kansas Entomol. Soc. 66(2)151–159.

Petersen, R. C. and K. W. Cummins. 1974. Leaf processing in a woodland stream. Freshwater Biol. 4:343–368.

Wagner, R., and E. C. Masteller. 1992. Long term population changes of Psychodidae (Diptera) from a steam recovering from sewage effluent and a control stream. Limnologica. 22(2):105–113.

Wolda, H. 1978. Fluctuations in abundance of tropical insects. Amer. Nat. 112(998):1017–1045.