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# Diurnal biting periodicity of parous *Simulium* (Diptera: Simuliidae) vectors in the onchocerciasis Amazonian focus

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**Abstract**

We describe the hourly patterns of parous biting activity of the three main simuliid vectors of human onchocerciasis in the Amazonian focus straddling between Venezuela and Brazil, namely, *Simulium guianense* s.l. Wise; *S. incrustatum* Lutz, and *S. oyapockense* s.l. Floch and Abonnenc. Time series of the hourly numbers of host-seeking parous flies caught in five Yanomami villages during dry, rainy, and their transition periods from 1995 to 2001 were investigated using harmonic analysis (assuming an underlying circadian rhythm) and periodic correlation (based on Spearman's *r*). Parous *S guianense* s.l. showed a bimodal activity pattern, with a minor peak in mid-morning and a major peak at 16:00 h. *S. incrustatum* exhibited mainly unimodal activity during either early morning or midday according to locality. *S. oyapockense* s.l. bit humans throughout the day mainly between 10:00 and 16:00 h but also showed bimodal periodicity in some localities. Superimposed on the endogenous, species-specific daily cycles, parous activity showed variation according to locality, season, air temperature and relative humidity, with biting being promoted by warmer and drier hours during wet seasons/periods and reduced during hotter times in dry seasons or transitions. The results are discussed in terms of their implications for blackfly biology and ecology as well as onchocerciasis epidemiology and control.


*Keywords:* *Simulium guianense* s.l.; *S. incrustatum*; *S. oyapockense* s.l.; Time-series; Harmonic analysis; Host-seeking activity; Onchocerciasis; Southern Venezuela

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## 1. Introduction

Human onchocerciasis transmission and severity is the result of continuous exposure of individual hosts to the bites of *Simulium* Latreille vectors of *Onchocerca volvulus* Leuckart. Consequently, quantification of the degree of host exposure, measured by vector density and the biting rate of flies on humans is important to parameterize models for transmission dynamics and control (Renz and Wenk, 1987; Dye, 1994; Basáñez et al., 2002). The most commonly used indicator of the degree of human exposure in onchocerciasis studies is the annual biting rate (Duke, 1968). This parameter, which describes the yearly number of flies attempting to obtain a blood-meal on a human, represents more truly a 'landing' than a 'biting' rate thus overestimating exposure. Being a summary measure, the annual biting rate gives no real indication of the temporal and spatial variation in both blackfly abundance and human exposure (Renz, 1987). Investigation of the monthly, daily, and hourly variation in blackfly biting activity, and in particular of the parous component of the fly population, would permit identification of months of the year and hours of the day during which transmission of onchocerciasis is potentially highest (Renz, 1987). Ideally, these studies should be accompanied by estimates of the amount of time that populations at risk spend on activities that expose them to vector bites during these months and hours, in order to obtain more accurate estimates of contact rates for transmission models (Bockarie and Davies, 1990; Renz et al., 1987).

We have already shown that three anthropophilic simuliid species are involved in onchocerciasis transmission in the Amazonian focus of southern Venezuela, namely *Simulium guianense* Wise s.l., *S. incrustatum* Lutz, and *S. oyapockense* Floch and Abonnenc s.l. Such studies have also revealed that spatial (altitude, locality) and temporal (seasonal) variation in the biting activity of these species, together with their contrasting vectorial efficiencies contribute differentially to exposure and transmission in this endemic focus (Basáñez et al., 1988; Vivas-Martínez et al., 1998; Grillet et al., 2001). *S. guianense* s.l. prevails during the transition between dry and wet seasons in the highland hyperendemic areas. In these areas, *S. guianense* s.l. acts as the main vector of *O. volvulus* despite its relatively low parous biting rate (median = 40 parous bites/person-day; range = 4–350), due to its high vector competence (Takaoka et al., 1984; Basáñez et al., 1995; Grillet et al., 2000, 2001). *S. incrustatum* plays a secondary vectorial role in hyperendemic settings, predominating mainly during the rains, rainy-dry and early dry seasons when its parous (and probably survival) rates are highest (median = 180 parous bites/person-day; range = 60–390) (Grillet et al., 2001). *S. oyapockense* s.l. is the prevalent species at lowland hypo- and mesoendemic forested areas, where it bites in very large numbers (median = 1920 parous bites/person-day; range = 1500–3300) during the dry and rainy seasons, compensating for its low vector competence (Shelley et al., 1987; Basáñez et al., 1988, 1995; Vivas-Martínez et al., 1998; Grillet et al., 2000, 2001).

Our results have also suggested that seasonal fluctuations of parous populations are correlated mainly with river level, with the dry season and the transition periods between seasons potentially contributing most to onchocerciasis transmission (Grillet et al., 2001). Less research has been conducted, however, on the patterns of hourly variation in biting activity for these simuliid species. Knowledge of these patterns would be important not only to help quantifying exposure but also to aid the design of sampling protocols that would maximize the efficiency of rapid entomological assessment (REntA) methods for the monitoring and evaluation of ivermectin-based control programmes (Basáñez et al., 1998; Vieira et al., 2005).

Blackflies exhibit a 24-h pattern of rest and activity, presumably driven by natural circadian rhythms timed or adapted to the predictable daily cycle of light and darkness, but readily modifiable by (exogenous) weather and environmental conditions, such as wind speed, rainfall pattern, temperature and humidity (Wenk, 1981; Crosskey, 1990). Adult females bite from dawn to dusk, but most activity occurs in peaks around particular times of the day.

Daily biting peaks are dependent on species, season, climatic conditions, parity status (e.g., pars and nullipars seeking bloodmeals at different times of the day), location and host availability (Duke, 1968; Wenk, 1981; Crosskey, 1990). Since host-seeking periodicity is highly regulated by the duration of the gonotrophic (blood feeding and oviposition) cycle, biting activity of parous females may provide insights into the duration of such cycle (Cheke, 1995) and the timing of oviposition (Duke, 1968). Short gonotrophic cycles and blood