Blackflies (Diptera : Simuliidae) in highland streams in Guatemala, with special reference to the seasonal prevalence of immature stages and voltinism

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Blackflies (Diptera: Simuliidae) in highland streams in Guatemala, with special reference to the seasonal prevalence of immature stages and voltinism*

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Abstract: Immature stages of blackflies were studied in uppermost part of 2 streams in Guatemalan highland, Sierra Madre. In total 5 species, *Gigantodax wrighti*, *Simulium* (*Simulium*) *tricornis*, *S.* (*S.*) *anduzei* and *S.* (*S.*) *jobbinsi* in descending order of abundance, were collected. *G. wrighti* and *S.* (*E.*) sp. were predominant and occupied more than 80% of the total specimens collected from each stream. All the 5 species appeared at higher density in the rainy season and the first half of the dry season than in the latter half of the dry season. From the head width distribution in each month, *G. wrighti* and *S.* (*E.*) sp. were found to be multivoltine species. *G. wrighti* had two generations in the rainy season to the first half of the dry season and possibly one generation in the latter half. *S.* (*E.*) sp. had 2 generations in the rainy season, and at least one more generation, possibly two, in the dry season.

Many studies on seasonal prevalence, growth and life history of blackflies have been undertaken (Sommerman *et al.*, 1955; Davies and Syme, 1958; Ladle and Esmat, 1973; Hansford, 1978; Wotton, 1978 *etc.*), but intensive studies have been restricted to the middle and high latitudes of the northern hemisphere. Little has been studied on Mesoamerican and Southamerican species except for the vector species of human onchocerciasis. In the present paper tropical highland blackflies in Guatemala were studied on seasonal prevalence of immature stages and voltinism, including a species of the genus *Gigantodax*. *Gigantodax* is one of the phylogenetically interesting genera, which is distributed from the southern end of South America to Mexican highland along the Andes and beyond the Isthmus of Panama.

STUDY AREA AND METHODS

Collections were made in 2 streams, the Tzojomá and the Sesenta Vueltas in Guatemalan highland, Sierra Madre, located north of Lake Atitilán as shown in Fig. 1. Both streams are small tributaries and rise near the ridge of the mountains, which has almost 3,000 m of altitude. They flow for about 100 m from the source on the gently inclined slopes, then run down along the steep slopes to the junctions with the main rivers. Sam-

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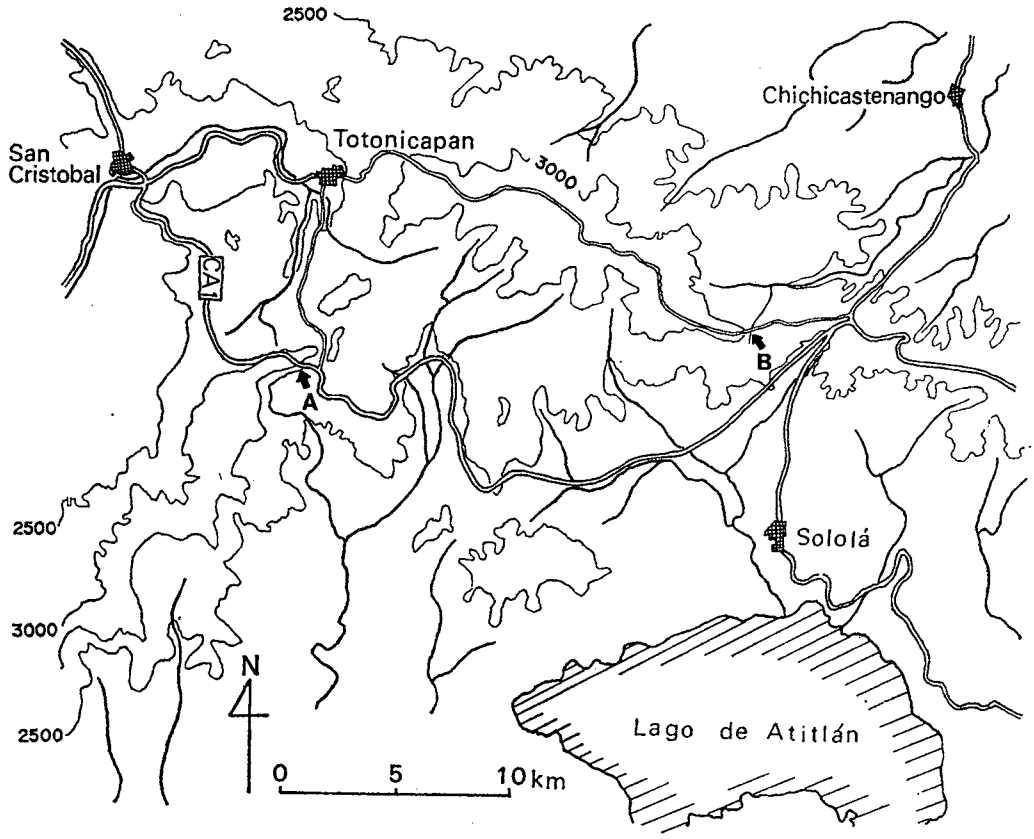

Fig. 1 Topography of study area
Arrows indicate the sampling sites. A: the Tzojomá Stream, B: the Sesenta Vueltas Stream.

pling sites were chosen in the uppermost, gently inclined part. The sampling site in the Tzojomá (A) is close to the highest point of the Central American Road No. 1 between Nahualá and San Cristobal Totonicapán, where the departmental border line between Sololá and Totonicapán lies. The Sesenta Vueltas crosses the National Road No. 1 about 6 km from Encuentros to Totonicapán. The site is situated at upstream of the crossing. Altitudes of the sites in the Tzojomá and the Sesenta Vueltas are 2,900 and 2,850 m, respectively. The site in the Tzojomá is surrounded by grassland and wheat fields, and the site in the Sesenta Vueltas by grassland with low shrubs and vegetable fields. The stream-bed consists of hard mud. Short hydrophilous grass grow out of water along the margins of the streams. The width and depth of the streams in the season of maximum water discharge were about 40 and 10 cm respectively, while in the season of the minimum water discharge, they were about 15 and 3 cm, respectively. Monthly change of mean maximum and minimum temperatures and precipitation in Totonicapán are shown in Fig. 2. The maximum temperature is almost constant throughout the year. The minimum temperature is variable, being higher in the rainy season than in the dry season. The water temperature in

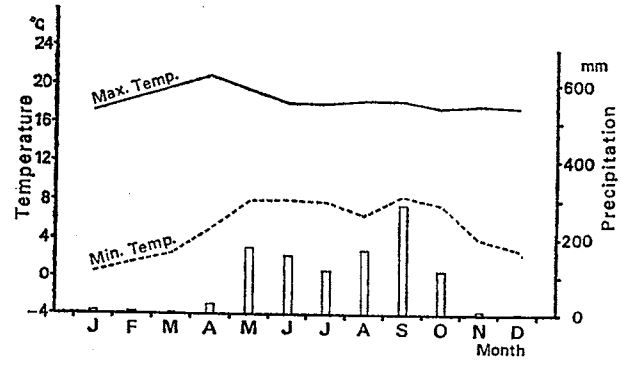

Fig. 2 Mean maximum, minimum temperatures and precipitation during 1954–1959 at Totonicapán

the Sesenta Vueltas was constant, approximately 12°C irrespective of time of measurement, except March 1979, when it was 16°C. The temperature in the Tzojomá fluctuated between 11 and 17°C, with a tendency towards being cooler in January to February and warmer in April to December. The valley of Tzojomá faces southwest and is surrounded by grassland, therefore the isolation in the afternoon may affect the ground and water temperatures, while the valley of the Sesenta Vueltas faces east, resulting in rather constant water temperature.

The rainy season generally begins in May and ends in October. Increased water discharge was observed 1 or 2 months after the beginning of the rainy season. The decrease was observed also 1 or 2 months after the end of the rainy season (Figs. 2 and 3). In the later half of the dry season, water level was very low, with only a slight trickle of water.

For investigation of seasonal prevalence, a unit time collection was adopted. Larvae and pupae attached to submerged plant matter were collected by forceps for 10 min. Thorough searching for simuliids on each substrate was made to avoid the bias to larger individuals only which are easier to find out and pick up. Once collection was started with a substrate, it continued till all simuliid larvae were completely picked up from the same substrate, then another substrate was taken. Sampling was carried out once a month. At each time 2 samples were taken by Okazawa in November 1977 to October 1978, and 1 sample by Takahasi in November 1978 to June 1979. All specimens collected were kept in 70% ethanol. After species identification, head widths of all larvae were measured.

Results

The species and number of individuals collected are shown in Table 1. In total, 5 species belonging to 2 genera were collected. In the Tzojomá, *Simulium* (*Eusimulium*) sp. was the most abundant and was followed by *Gigantodax wrighti and Simulium* (*Simulium*) *tricornis* in descending order, while in the Sesenta Vueltas, *G. wrighti* was the most abundant followed by *S.* (*E.*) sp., *S.* (*S.*) *tricornis, S.* (*S.*) *anduzei* and *S.* (*S.*) *jobbinsi. G. wrighti* and *S.* (*E.*) sp. were predominant species; a total of the 2 species occupying more than 99% of the total specimens collected in the Tzojomá and 81% in the Sesenta Vueltas.

Seasonal prevalence of each species is shown in Fig. 3. *G. wrighti* was abundant during the period from the rainy season to the first half of the dry season, but scarce in the latter half of the dry season. It seems that there existed 3 peaks in abundance, 2 of them in the rainy season and 1 in the dry season. However, at the Sesent Vueltas during the rainy season only 1 blunt peak in July to October was observed. All the peaks in the Sesenta Vueltas appeared later than

Table 1 Number of blackfly larvae and pupae collected in 2 streams in highland Guatemala during a period of 1 year, from November 1977 to October 1978 in the Tzojomá Stream and from May 1978 to April 1979 in the Sesenta Vueltas Stream

Species	Tzojomá (A) No. of			Sesenta Vueltas (B) No. of		
	Larvae	Pupae	%*	Larvae	Pupae	%*
Gigantodax wrighti Vargas, Martínes and Díaz	945	6	37.0	1,399	10	66.3
Simulium (*Simulium*) *anduzei* Vargas and Díaz	0	0	0	98	4	4.8
Simulium (*Simulium*) *jobbinsi* Vargas, Martínez and Díaz	0	0	0	89	2	4.3
Simulium (*Simulium*) *tricornis* De León	2	0	0.1	203	0	9.5
Simulium (*Eusimulium*) sp.	1,601	17	62.9	309	11	15.1
Total	2,548	23	100.0	2,098	27	100.0

* Percentage of number of larvae and pupae to the total collections.

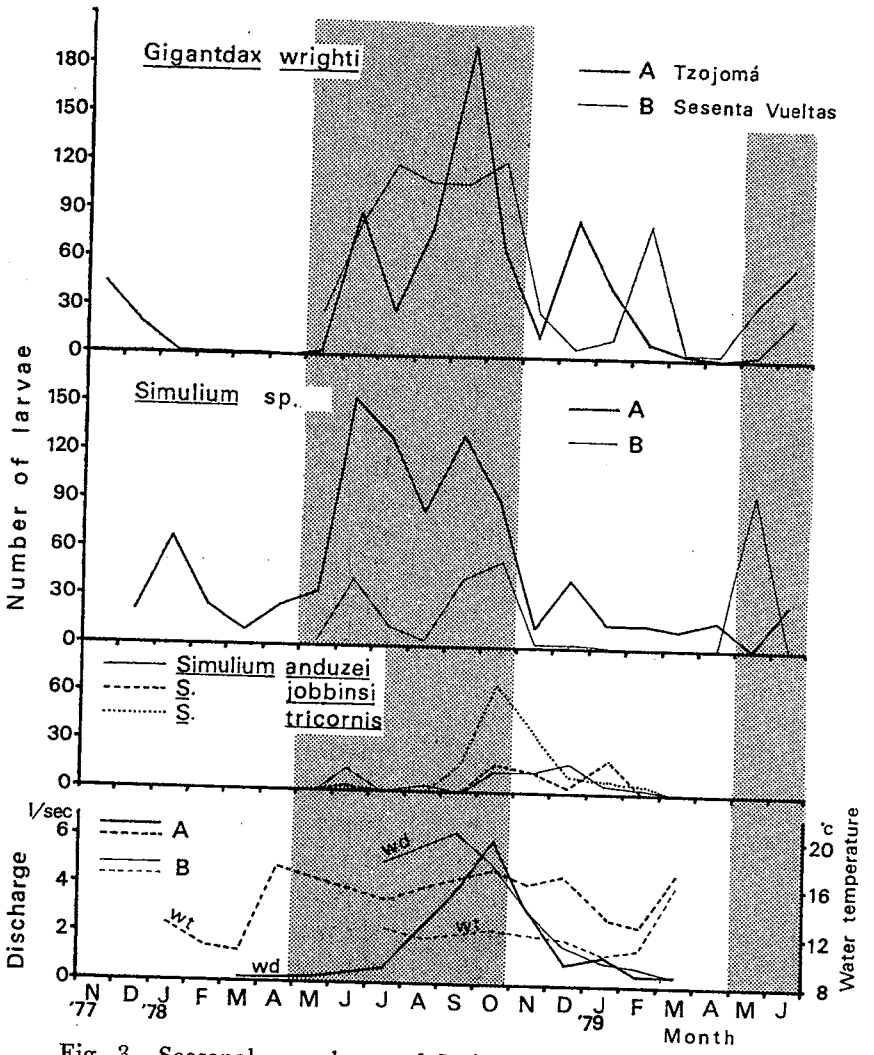

Fig. 3 Seasonal prevalence of 5 simuliid species and stream conditions

The rainy season is shown by patched area. wd: volume of water discharge, wt: water temperature.

those in the Tzojomá. Seasonal prevalence of *S.* (*E.*) sp. was similar to that of *G. wrighti*. It was abundant in the rainy season and scarce in the dry season. There were 2 clear peaks in the rainy season in both streams and 1 peak in the dry season in the Tzojomá though it was absent in the Sesenta Vueltas. Larval density of both species suddenly increased at the beginning of the rainy season, when the water discharge was still low. Other 3 species show similar patterns, that is, a few individuals appeared in the beginning of the rainy season, and then the density increased at the end of the rainy season. The relatively high density level was maintained in the first half of the dry season.

Figure 4 shows the size distribution of larval head widths of *G. wrighti* for each month in the 2 streams. During the period, from May to December, or from the beginning of the rainy season to the month when the water discharge decreased, 2 clearly distinguishable successive cohorts were observed in both streams. In the middle of the dry season, young larvae of another cohort appeared, but this cohort disappeared in the late dry season before maturing in the Sesenta Vueltas. This suggests that *G. wrighti* has at least 2 generations, possibly 3 generations per year. The appearance of young larvae corresponded to the peaks in the seasonal prevalence. The first generation in the rainy season appeared without overlapping with the generation in the dry season. This generation appeared earlier in the Sesenta Vueltas than in the Tzojomá, but the other generations in the Sesenta Vueltas appeared later than in the Tzojomá. In *S.* (*E.*) sp.

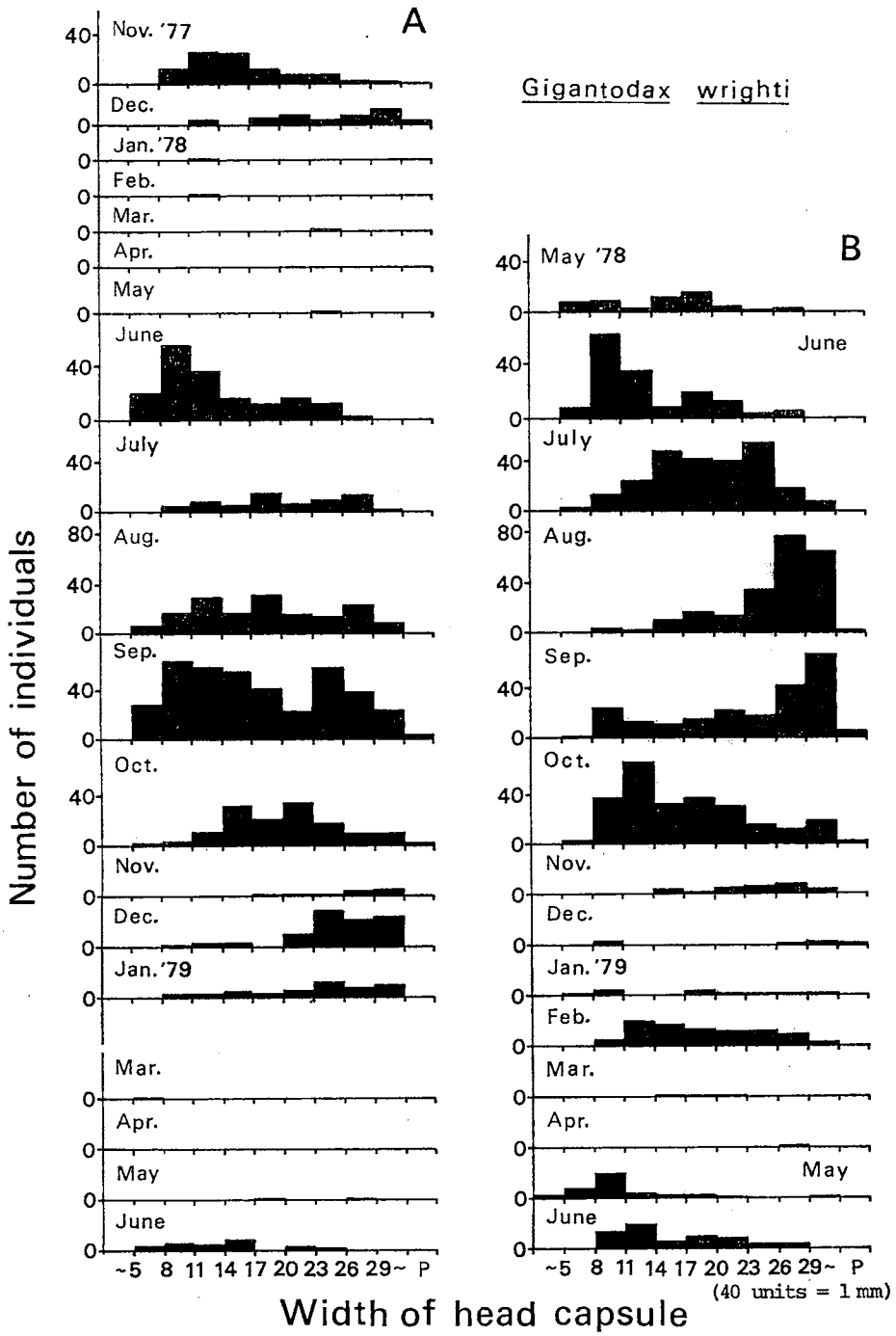

Fig. 4 Frequency distribution of head-width of *Gigantodax wrighti* in 2 streams
A: the Tzojomá Stream, B: the Sesenta Vueltas Stream, P: pupae.

at least 3 generations could be detected in the Tzojomá, although 2 consecutive generations tended to overlap each other (Fig. 5). Young larvae appeared in each of the 3 periods, June, August to September and December to April. In the dry season, the density was very low, however this species appeared to pass 2 generations. In the Sesenta Vueltas, 2 generations were recognized in the rainy season. The first generation appeared in the beginning of the rainy season, May (1979) or June (1978). It is not clear when the second one appeared, but the increased density of small larvae in August and September suggests the existence of another generation. In the dry season, larval density

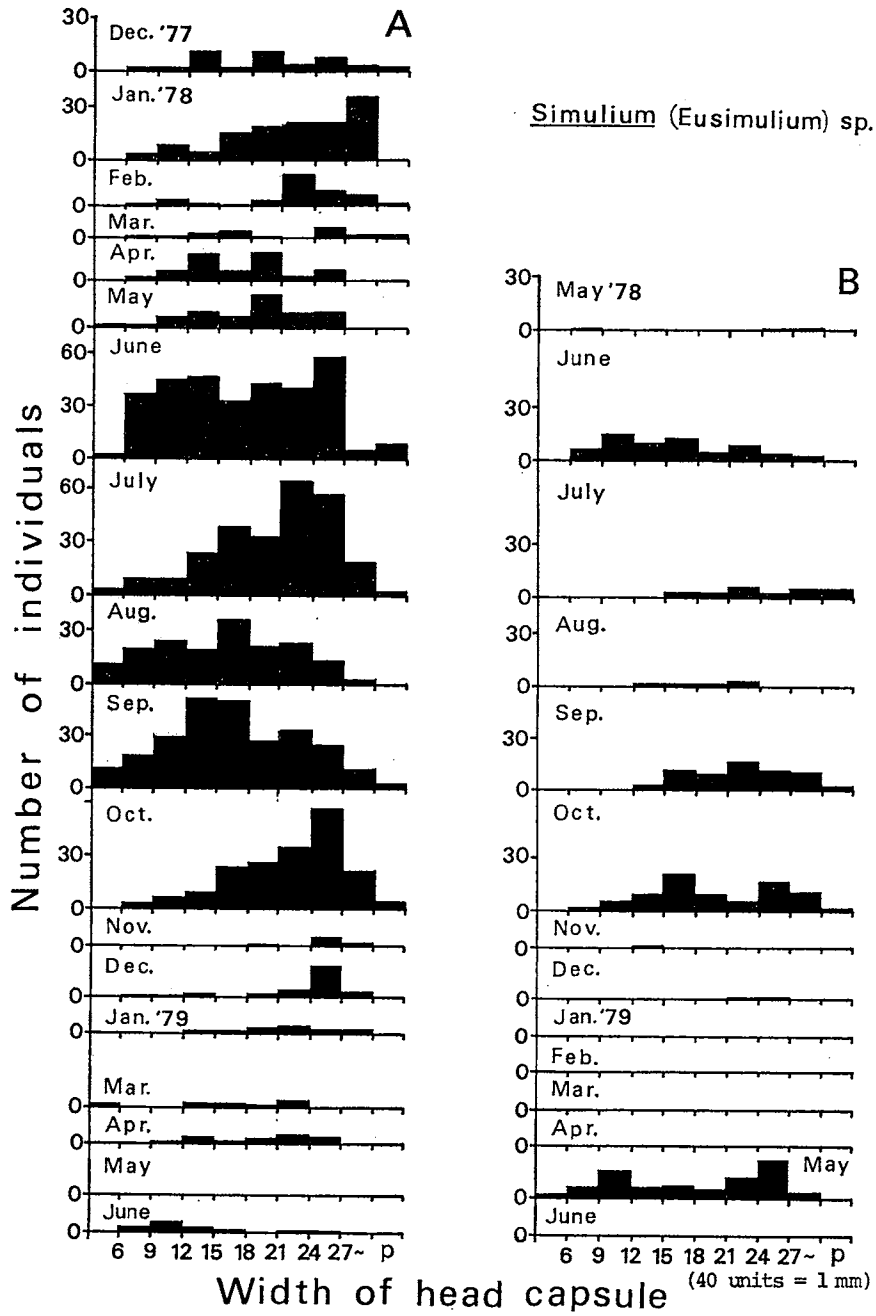

Fig. 5 Frequency distribution of head-width of *Simulium* (*Eusimulium*) sp. in 2 streams
A: the Tzojomá Stream, B: the Sesenta Vueltas Stream, P: pupae.

was very low, especially in January to April, 1979, no larvae were collected.

Discussion

Simulium (*Eusimulium*) sp. was treated by Dalmat (1955) and Vargas and Díaz Najera (1957) as *S.* (*E.*) *aureum* (Fries). But the Guatemalan specimens are morphologically different from *S.* (*E.*) *aureum* redescribed by Davies (1966) and Peterson (1977) in some characters such as the shapes of basimere, ventral plate of male, cercus of female and head spots of larva. Stone (1965) stated that *S.* (*E.*) *aureum* in North America is an unrevised species complex. Therefore, we treated here the Guatemalan specimens as *S.* (*E.*) sp., not as *S.* (*E.*) *aureum*. *S.* (*E.*) sp. is closely related to *S.* (*E.*) *aureum* and assigned as a member of the *aureum*-group

of subgenus *Eusimulium* defined by Davies (1966).

On the vertical distribution of immature stages of blackflies in tropical America, only the work of Dalmat (1955) is available. In his study, he divided the altitude into 7 categories. The majority of individuals of *G. wrighti, S.* (*E.*) sp. and *S.* (*S.*) *tricornis* were collected in the highest and the second highest categories, above 1,800 m of altitude, though he did not show the number of samples taken from each category. The 2 streams under the present study belong to the highest category of the Dalmat's division, above 2,100 m of altitude. The present authors collected these 3 species also in other streams above 2,200 m of altitude. *G. wrighti* and *S.* (*E.*) sp. were found mainly in the uppermost of the streams, some of which dried up in the later half of the dry season. No larvae and pupae were collected by more intensive survey below 1,500 m. From those, these 3 species can be called as the highland species. They may breed in the streams above 1,800 m of altitude.

Difference in the relative abundance of each species between the 2 streams in the present study might be derived from the difference of water velocity. *S.* (*E.*) sp. prefers lower velocity than *G. wrighti.* The Sesenta Vueltas is relatively steeper than the Tzojomá and the water velocity in the Sesenta Vueltas is higher than that in the Tzojomá.

Life cycles or voltinism of the species in the present study or taxonomically related species are known very little. *S.* (*E.*) *aureum* is comparable with *S.* (*E.*) sp. Rubzow (1959–1964) in Europe, Lewis and Bennett (1973), Ezenwa (1974) and Back and Harper (1979) in North America reported the life cycle of *S.* (*E.*) *aureum.* From these studies, it can be summarized that (1) *S.* (*E.*) *aureum* overwinters in the egg stage, (2) larvae appear in the water temperature range of 10 to 20°C in northern part of the distribution, but (3) the number of generations per year varies 1 to 3, probably depending on the length of breeding period under varying environmental conditions. In the 2 streams of the present study, water temperature varied between 10 and 20°C throughout the year, without any marked drop in winter. The larvae of *S.* (*E.*) sp. appeared all year round, though the density of larvae decreased in the late dry season.

Dalmat (1955) studied the growth period of *G. aquamarensis* in Guatemala. In his work, *G. aquamarensis* required 50–63 days for larval development and 5–9 days for pupal development. Judging his results and our observation that variously sized larvae were always present at high density from January through September (unpublished, no data available in rest 3 months from October to December), *G. aquamarensis* may be multivoltine in Guatemala. *G. wrighti* was bivoltine or possibly multivoltine in highland Guatemala. These suggest that the species of the genus *Gigantodax* in the tropical region are not univoltine, but multivoltine.

As the breeding stream of *G. aquamarensis,* only one stream, Río Aguas Amargas, Zunil, Quezaltenango, has been known, in which water discharge is fairly constant, approximately more than 5 liters/sec, throughout the year. pH is very low, being 4.5. Only the larvae of *G. aquamarensis* were collected in that stream. The larvae appeared successively all year round. On the other hand, in the breeding streams of *G. wrighti,* water discharge was seasonally changed. In the late dry season larvae of *G. wrighti* almost disappeared in the uppermost part of the streams. It is still unknown in what stage and where the majority of this species pass the late dry season.

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摘　要

グァテマラ共和国の高原のブユとその個体数密度の季節変動および化性

グァテマラ共和国の高地，シエラ・マドレの標高2,800～2,900 m から流れ出る二つの川の最上流で，ブユ相，幼虫と蛹の個体数密度の季節変動，およびその化性を調べた．採集個体数の多い順に，*Gigantodax wrighti*, *Simulium* (*Eusimulium*) sp., *Simulium* (*Simulium*) *tricornis*, *S.* (*S.*) *anduzei*, *S.* (*S.*) *jobbinsi* の2属5種が採集された．*G. wrighti* と *S.*(*E.*) sp. は特に個体数が多く，この2種の合計はそれぞれの川の総採集個体数の 80% 以上を占めた．採集された5種の個体数密度は雨季の始まりから乾季の前半まで高く，乾季の後半は低い．各月の幼虫の頭幅値の頻度分布から，*G. wrighti* は雨季に2世代，乾季に1世代，計年3世代，*S.*(*E.*) sp. は雨季乾季共に2世代ずつ，計年4世代経過するものと考えられる．