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Bionomics of black flies (Diptera: Simuliidae) in Costa Rica. III. Larval population dynamics in five selected streams*

by

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Abstract: Studies on black fly larval populations in five streams in the Central Valley of Costa Rica during July 1968 to July 1969 indicated that a single observation on a stream would not necessarily evaluate its relative importance as a black fly producer and that more than one sampling is needed to obtain reliable and representative data.

Among the subgenera studied *(Hemicnetha, Psilopelmia* and *Simulium)* information on larval size, maturity and population levels established that hatching of larvae continued during both dry and rainy seasons. Although the population levels dropped during the dry season in three of the five study streams, there was no consistent seasonal influence on larval populations and the differences observed were greater between streams than between seasons.

Information about the dynamics of black fly larval populations is considered essential in planning meaningful surveys, to give guidance in selecting appropiate time schedules for sampling, sample sizes, and species distribution and to better understand the epidemiology of the transmission of pathogens by these insects.

In population studies of freshwater invertebrates it is very important to choose adequate sampling techniques in order to obtain reliable data; this is particularly difficult when studying simuliid larvae and pupae because of the diversity of microhabitats occupied by different species generally found in the same stream. A few examples of sampling and population studies in different parts of the world are those of Disney (1972) in Cameroon; Maitland & Penney (1969) in

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Scotland; Obeng (1967) in England; Carlsson (1967) in Northern Sweden; Wood & Davies (1966) and Lewis & Bennett (1974) in Canada; Anderson & Dicke (1950) and Reisen (1976) in the United States; and for the Neotropical Region Dalmat (1955) in Guatemala.

Because our knowledge of these aspects of black fly larval biology in this region is very limited in spite of its importance, one of our primary objectives has been to obtain data on seasonal and annual distribution and population changes (Vargas & Travis, 1973; Vargas *et al.*, 1977; and Travis & Vargas, 1978).

METHODS

Five streams located in the central valley of San José, Costa Rica previously described and grouped in categories (Vargas & Travis, 1973) were selected for the study. Stream N° 14 of category I has a bed of gravel, stones and large boulders; it is mostly fast and turbulent, with waterfalls, and has a small amount of vegetation. The other four streams (N° 4, 8, 15 and 44) belong to category II, with a bed of sand and stones; they are fast and turbulent only in intermittent areas, with a small to moderate amount of trailing vegetation.

Larval samples were collected weekly from each stream five times during each of the following three different periods during wet and dry seasons:

1) Towards the end of the wet season (W), 24 September to 22 October, 1968.
2) At the beginning of the dry season (ND), 3 to 30 December, 1968.
3) During the dry season (D), 18 February to 18 March, 1969.

All stages were collected from vegetation and fixed by placing directly in alcohol portions of plants to which larvae were attached. Specimens on rocks were scraped together with fine forceps and moved to alcohol vials.

The lengths of 50 larvae selected at random from each of the weekly collections were measured to determine hatching and growth patterns. The percentage of larvae with mature respiratory histoblasts and the relative densities of the populations studied at subgeneric level were determined from a sample of 100 larvae collected from both rocks and vegetation at each observation site of the streams. A subjective estimate of the larval populations was made in the field at each collecting station. The code for these estimates was as follows:

0 = No larvae
1 = Less than 5 larvae per unit, 25 cm^2, leaf or rock.
2 = 6-20 larvae per unit.
3 = 21 or more larvae per unit.
\+ = Larvae on more than half the units.
– = Larvae in less than half the units.

RESULTS

Two easily recognized types of larvae were found in five streams: large black larvae of the subgenus *Hemicnetha* and small light-colored ones of the subgenera *Psilopelmia* and *Simulium*.

In Table 1 are summarized the lengths of larvae of the two subgenera *Psilopelmia* and *Simulium*. The entries in the table are based on measurements of

250 larvae, 50 from each of the five weekly collections from each stream. The average lengths of the larvae varied between streams and seasons by only about one millimeter, ranging from 2.6 to 3.7 mm. The bar graphs in Figure 1 give a visual presentation of the data in Table 1, but are presented only for the dry season, as a model for interpretation, because the population densities were so similar for each of the three seasons. Each graph depicts the measurement information for 50 larvae; bar 1 is composed mostly of newly hatched larvae, bars 2 and 3 represent intermediate growth stages and bar 4 mature or nearly mature larvae. Graphs for stream 15 are not included since the water was diverted by farmers so that the data are not complete nor representative.

TABLE 1

Lengths (mm) of Psilopelmia *and* Simulium *larvae from five streams*

SEASON*	Nº 4	Nº 8	Nº 14	Nº 15	Nº 44
W	2.8	3.1	3.1	3.5	3.1
BD	2.6	2.7	3.2	3.7	2.7
D	3.4	3.1	3.0	dry	2.6

* W = wet season, 24 September - 22 October 1968; BD = beginning of dry season, 3 - 30 December 1968; and D = dry season, 18 February - 18 March 1969. Costa Rica, Central America.

TABLE 2

Average percentages of Psilopelmia *and* Simulium *larvae with mature respiratory histoblasts from five streams*

SEASON*	Nº 4	Nº 8	Nº 14	Nº 15	Nº 44
W	2.0	2.0	4.8	42.4	16.0
BD	4.8	6.4	17.2	16.4	2.4
D	8.4	16.4	8.8	dry	5.2

* W = wet season, 24 September - 22 October 1968; BD = beginning of dry season, 3 - 30 December 1968; and D = dry season, 18 February - 18 March 1969. Costa Rica, Central America.

Table 2 summarizes the percentages of larvae with mature black respiratory histoblasts collected at each of the five streams; each entry is based on 500 larvae, 100 for each of the five weekly collections.

TABLE 3

Relative abundance of Hemicnetha, Psilopelmia *and* Simulium *larvae in five weekly samples on vegetation (V) and on Rocks (R)*[1]

STREAM	1		2		3		4		5	
N°	V	R	V	R	V	R	V	R	V	R
					Wet Season					
4	1	1	0	1	0	0	0	1	0	1
8	11	88	30	94	10	79	9	93	18	64
14	1	22	2	2	0	3	3	16	1	10
15	14	30	0	0	2	5	7	10	4	9
44	0	12	0	9	1	6	1	16	2	5
					Beginning of the dry season					
4	0	0	0	0	0	0	0	0	0	0
8	9	61	19	94	22	88	47	90	92	65
14	0	7	10	6	0	6	5	13	6	10
15	1	2	2	7	1	6	2	7	3	17
44	11	19	3	17	4	32	1	47	4	50
					Dry Season					
4	1	0	0	0	0	0	0	0	0	0
8	0	71	0	7	40[2]	10[3]	2[4]	20[5]	0	4
14	2	22	3	8	9	7	42	32	34	94
15	dry	-	-	-	-	-	-	-	-	-
44	3	2	0	8	0	12	0	4	0	1

1 The differences between the figures entered in the table and 100 are the percentages of *Psilopelmia* and *Simulium* larvae.
2 20 specimens
3 18 specimens
4 50 specimens
5 70 specimens

The percentages of specimens of *Hemicnetha, Psilopelmia* and *Simulium* in the samples from vegetation and rocks are summarized in Table 3. Locations where less than 100 larvae were found are indicated.

Newly hatched larvae of *Psilopelmia* and *Simulium* were more numerous during the wet season in stream 4: in streams 8, 14 and 44 they were less numerous than during the dry season.

At the beginning of the dry season there were more newly hatched larvae than during the wet season in all streams, and more first instar larvae than during the dry season in streams 4 and 8 and less in streams 14 and 44.

Mature larvae were more numerous during the wet season than during the dry season in stream 14; they were approximately equal during the wet and dry seasons in streams 8 and 44 and less numerous in the wet than in the dry season in stream 4.

During the beginning of the dry season there were more mature larvae than during the wet season in stream 14; in stream 4 the mature larvae were approximately equal during both these seasons, but less in streams 8 and 44.

During the beginning of the dry season the mature larvae were more numerous in stream 14 than during the dry season and less in streams 4, 8 and 44.

Because many newly hatched larvae on rocks (mostly *Hemicnetha)* were missed, the measurement data of specimens from this habitat were of limited use in making comparisons.

The populations of *Hemicnetha* larvae observed were adequate only for summary comments on the larval sizes during the wet season and beginning of the dry. There were fewer larvae of all stages during the wet season. In general, the total was higher than that of *Psilopelmia* and *Simulium.* Although the difference was smaller during the dry season.

In streams 4 and 8, mature larvae of all subgenera increased during the dry season.

The population estimates indicated that there were more larvae in most of the streams during the wet part of the year. The most variable populations recorded were in stream 15 but this could have been because of the flow manipulation.

In stream 14, the larval code 3+ for 21 or more larvae per unit was too low, as the populations greatly exceeded the code estimates. At the beginning of the dry season the populations of most of the other streams began to show reductions, while they increased in 14; this trend continued into the dry season. Stream 44 also maintained high populations while streams 4 and 8 had sharp decreases during this period.

The stream temperatures during the weekly observations during each of the three rainfall seasons varied from 14 to 26 C with the greatest range (14-26 C) ocurring during the dry season. The range of temperature for the five streams was: stream 4, 17-20 C; stream 8, 17-22 C; stream 14, 17-26 C; stream 15, 15-19 C and stream 44, 15-19 C.

DISCUSSION AND CONCLUSIONS

The techniques for collecting representative samples of immature simuliid populations all have advantages as well as disadvantages when sampling in any particular area, especially because of the microhabitat preferences of different species. In our studies, one of the methods employed by Obeng (1967) of collecting during 30 minutes from all available substrata gave satisfactory results. Changes in populations are related to seasons (Reisen, 1976; Lewis and Bennet, 1974) particularly in regions of marked temperature and climatic variations. In Costa Rica, although population levels varied during the wet and dry parts of the year, with some striking reductions as the climate changed from wet to dry, the season did not strongly affect the frequency of new larvae being added to the stream system, as indicated by the data in Tables 1, 2 and 3 and the bar graphs in Fig. 1. The numbers hatching were less during the dry season in some of the streams, were about equal in all seasons in others, and in one stream (N^{O} 14) they were greater during the dry than during the wet season.

Data for average length of larvae when correlated with streams and seasons suggest that the differences between streams were greater than between seasons. Also, the striking differences in percentage of larvae with mature histoblasts seem to be more related to the characteristics and variations of the microhabitat rather than to seasonal changes.

The data in Table 3 show clearly that the *Hemicnetha* larvae prefer to attach to rocks and the *Psilopelmia* and *Simulium* to vegetation substrates. Maitland & Penney (1969) recorded the microdistribution of larvae and pupae in a Scottish river concluding that the larvae were mostly confined to the anterior part of the upper surface of the boulders facing the current. The qualitative observations we have made in Costa Rica have shown the reverse to be the case, most larvae being found attached to the posterior part of rocks. Larvae and pupae also preferred smooth leaves for attaching than the rough and hairy ones.

At least part of the seasonal replacement rates were related to pollution; the more polluted streams maintained higher larval populations.

Dalmat (1955) found in Guatemala all stages of *Simulium ochraceum* all year round but the adult populations showed two abundant peaks, the most pronounced in January and August, coinciding with maximum larval production in April and October. He also found that *Simulium metallicum* ocurred in great numbers throughout the year in contrast to *Simulium ochraceum* which apparently behaves in more cyclic patterns, and that *Simulium callidum* showed numerous fluctuations, suggesting that this species has more generations per year than the others. Because we treated population samples subgenerically and Dalmat's data refer to separate species a direct comparison cannot be made, yet it seems that in general, black fly populations in the Neotropical Region are high throughout the year, with numerous overlapping generations and that there is no marked seasonal species succession as described by other workers in the Nearctic Region (Lewis & Bennett, 1974; Reisen, 1976).

Among the most important environmental factors influencing the larval populations are: food supply, current velocity, rainfall and spates, substratum and other physicochemical conditions, associated vegetation and pollution. More recently, the effect of predators and parasites has been given more attention by several workers (Anderson & Dicke, 1960; Welch, 1963; Ezenwa, 1973; Ebsary & Bennett, 1975). In Costa Rica Mermithid and Microsporida parasites have been observed in addition to chironomid predators and we are presently assessing their importance in regulating the natural populations.

An examination of the data, especially in Table 3, does give some guidance on intervals necessary to examine the streams to determine their black fly productivity. Since the observations are weekly for 4 weeks, with a lapse between the weekly observations of about a month, it is possible to summarize the data on weekly, biweekly, triweekly, monthly and bimonthly intervals and likewise on the basis of seasons. The data show that for most streams, monthly or bimonthly intervals will give a fair idea of the productivity. The best single time of observation and sampling might be sometime between the middle and the end of the wet season.

RESUMEN

Se estudió las poblaciones larvales de simúlidos en cinco corrientes del Valle Central de Costa Rica de julio 1968 a julio de 1969. Se determinó que es necesario más de un muestreo de cada corriente para obtener información confiable sobre su importancia relativa como productor de simúlidos.

Los datos sobre tamaño de larvas, su madurez y niveles de población mostraron que la eclosión es continua durante todo el año. Sin embargo, aunque se

encontró fluctuaciones de las poblaciones larvales, éstas no fueron el resultado de influencias estacionales, sino más bien las diferencias fueron mayores entre las corrientes que entre las épocas del año. Las poblaciones más grandes de formas inmaduras se encontraron en las corrientes contaminadas.

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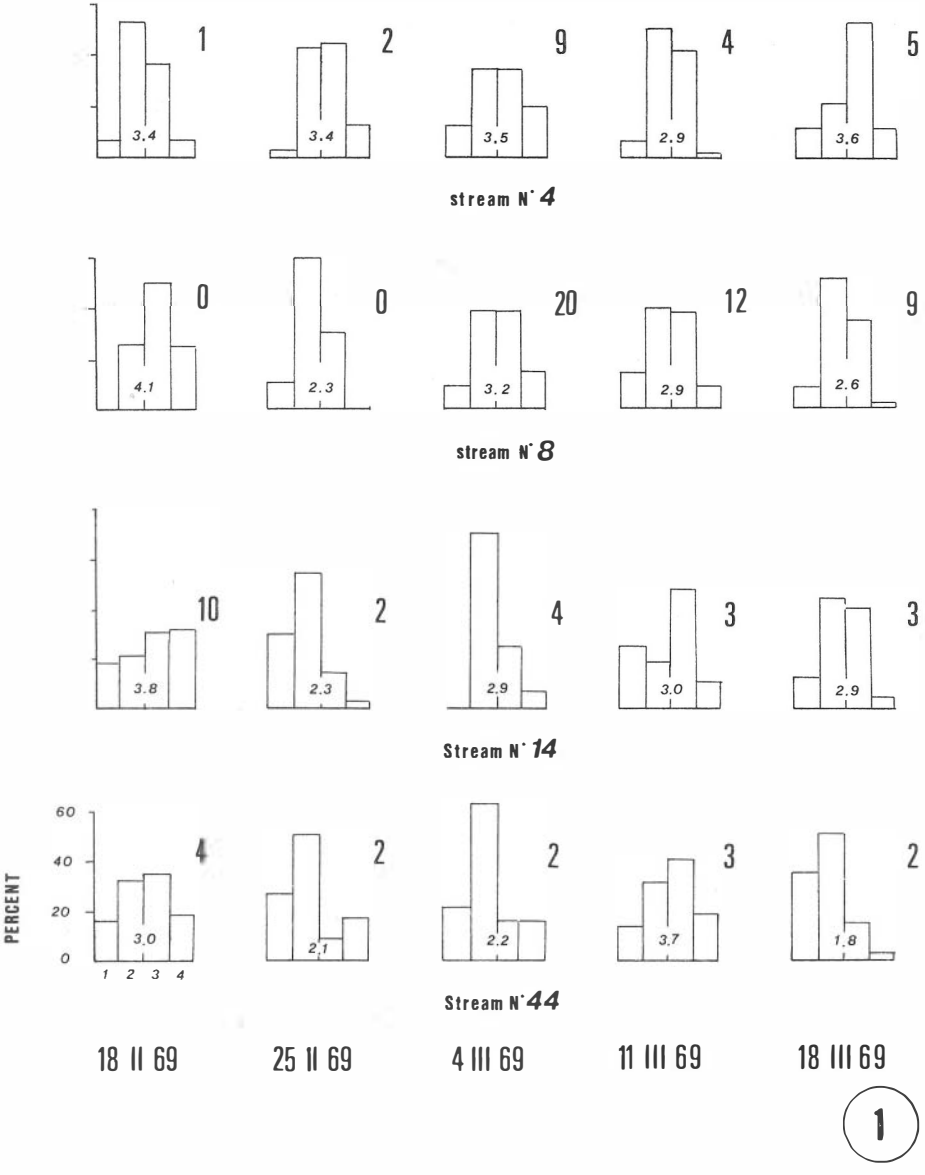
Fig. 1. Diagrams of larval size *(Psilopelmia,* and *Simulium)* at weekly intervals during the dry season; 18 February to 18 March. (Code for bar graphs, 1 = 0.5 to 1.0 mm; 2 = 1.1 to 3.0 mm; 3 = 3.1 to 5.0 mm; 4 = 5.1 to 7.0 mm; figures in graph are average sizes in mm, figures at upper corner of graphs are numbers of larvae/100 with black histoblasts. Costa Rica, Central America.


1
3.4
2
3.4
9
3.5
4
2.9
5
3.6
stream N° 4
0
4.1
0
2.3
20
3.2
12
2.9
9
2.6
stream N° 8
10
3.8
2
2.3
4
2.9
3
3.0
3
2.9
Stream N° 14
PERCENT
60
40
20
0
1 2 3 4
4
3.0
2
2.1
2
2.2
3
3.7
2
1.8
Stream N° 44
18 II 69
25 II 69
4 III 69
11 III 69
18 III 69

1