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A Community of simulium species in the Vaal River near Warrenton

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As the difference between individual samples was small, larvae from only one stone sample were analysed to determine the percentage distribution of larvae from consecutively collected stone samples. From the 22nd July until 11th September 1977, samples of *S. chutteri* larvae and pupae were collected from individual stones from the rapids at Witrand, at four day intervals. In the laboratory these samples were then analysed for size frequency, distribution of larvae and the number of pupae were also recorded.

There were however certain shortcomings in this method. Only one stone sample was taken on each sampling occasion and stone samples collected already had a large stabilized population on them. The interval between collection of stone samples (four days) may also have been too long to indicate minor changes. Stones were also taken from within a rapid where a large population of Simuliidae occurred and continuous drifting of large larvae would add confusion to the determination of the duration of the larval life cycle. The occurrence of large numbers of pupae in the earliest samples also would not allow for accurate determination of the larval life cycle of *S. chutteri*. As samples were very large, laboratory analysis involved a lot of work and was very time consuming.

Owing to these shortcomings it was decided to modify future observations in the field as follows: A number of two metre metal rods each with five attached artificial substrates were placed in a fast flowing gulley in the river at a site about 35 m upstream of the top end of the study rapid where water current velocities were similar to those occurring in the rapid. As a large slower-flowing expanse of river occurred upstream of this gulley the chances of colonization of artificial substrates by disturbed larger larvae were thus considerably reduced.

Monitoring simuliid populations using artificial substrates in this selected area to determine the life cycle duration of *S. chutteri* larvae was carried out from the 17th September to the 5th October 1979, from the 17th to the 31st January 1980 and again from the 21st July to the 13th August 1980. The metal rods with attached

artificial substrates were removed one at a time, at two to three day intervals. Substrates with attached organisms were individually preserved in formalin for later analysis. In the laboratory larvae and pupae were counted and results expressed as frequency distributions in percentages of the total numbers found on each substrate. In this way the effect of sample size in comparing samples collected on different days was eliminated.

Both for the samples from stones and for those from artificial substrates, histograms representing the percentage of larvae in various instars were drawn up for each sampling date. Cohorts of the various instars could then be followed through for a period of time, allowing estimates of the duration of the whole or parts of the larval stage to be made.

c) Pupae

For the determination of the duration of the pupal stage of *S. chutteri* a stone with attached larvae and pupae was collected from the rapids and transported to the laboratory in a bucket of water on several occasions (August, October 1978, February, March, April, July, August, September 1979 and June 1980).

In the laboratory the stone was placed in a small aquarium fitted with an aerator pump and airstone and filled with river water previously filtered through a net of 92 µm pore size. The stone was left in the water for a few minutes until a fair number of larvae had become detached and had settled on the sides of the aquarium. Final instar larvae pupated on the glass sides of the aquarium within 12 hours. For the first 48 hours the aquarium was checked every 12 hours for newly formed pupae and the positions of these were marked by ringing the outside of the aquarium around each pupa with different coloured waterproof inks for every 12 hour period. After the initial 48 hour period regular observations on the pupae were made and the time of eclosion was recorded. Aquarium temperature was measured at various times during the day and night and maximum and minimum temperatures were noted. On two occasions, July and August 1979, an additional aquarium was set up

with a thermostatically controlled heater. A comparison was then possible between the controlled temperature samples and samples kept under fluctuating ambient temperatures.

In considering possible responses to variation in day length, daylight duration from sunrise to sunset was calculated for the fifteenth day of each month (Kahoun, 1978).

6.3 RESULTS AND DISCUSSION

6.3.1 The number of larval instars in the life cycle of *S. chutteri*

First instar larvae in Simuliidae are always easily recognised by the presence of an egg burster and the final instar larvae are distinguishable from other larvae by the presence of separated cervical sclerites. Intermediate larval instars shown in Figure 17 were recognized from size frequency studies carried out on representative collections of larvae from various dates (Tables 5 to 7, Figs 18 to 21).

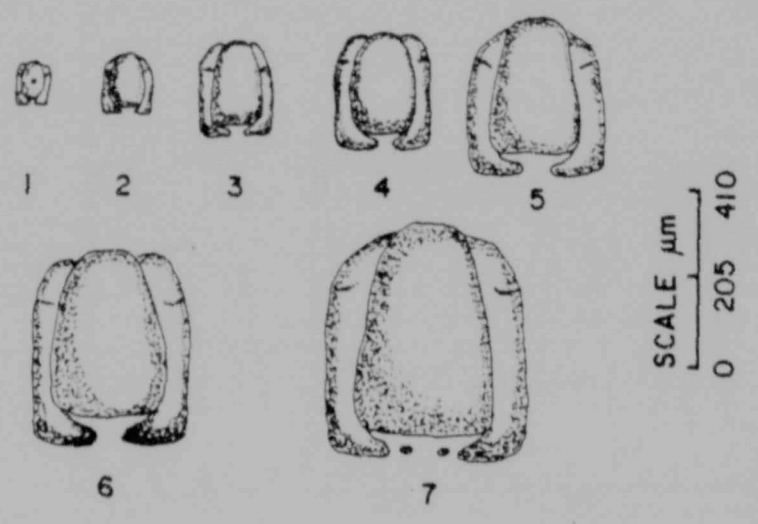

FIGURE 17: Dorsal view of head capsules of *S. chutteri* instars one to seven

From Figures 18 and 19 it is immediately apparent that there were seven distinct size classes in September 1977 and March 1979, but more than seven in June and July 1979 (Figs 20 and 21). This apparent anomaly will be discussed in further detail below.

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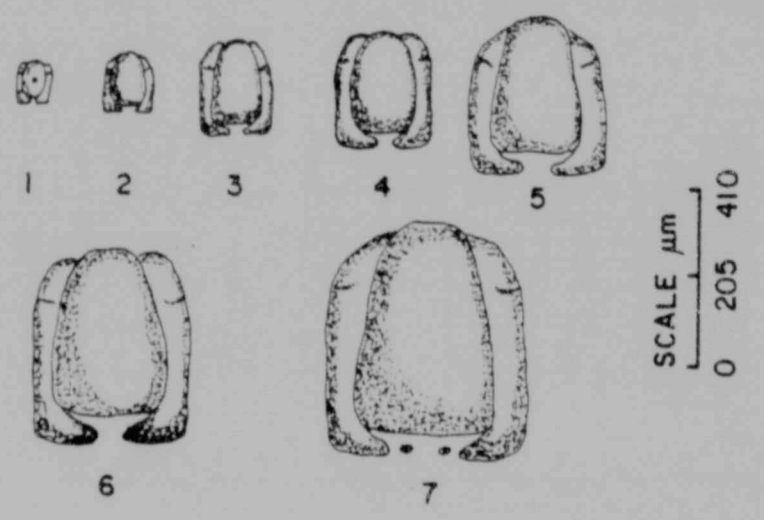

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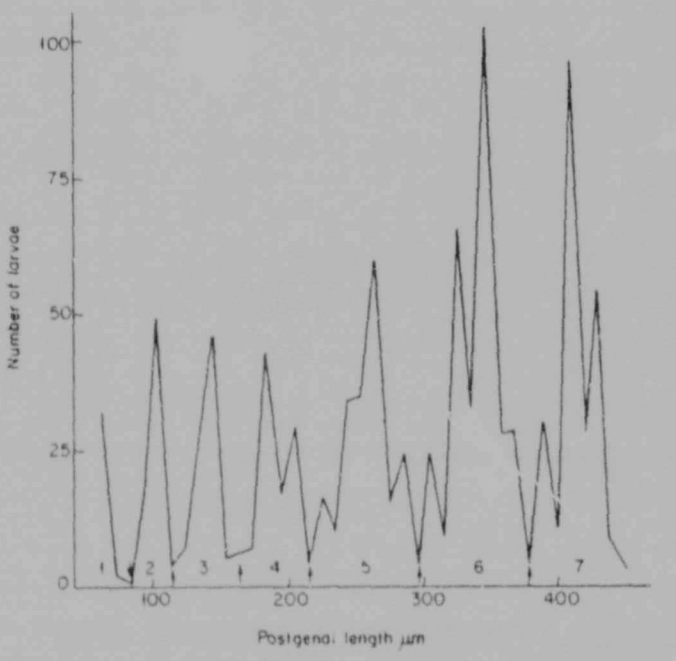

FIGURE 18: Postgenal length frequency distribution of 1 016 *S. chutteri* larvae collected 11 September 1977. Arrows show the limits of each instar. Note the multiple peaks in the fourth to seventh instars; these are indicative of sexual dimorphism

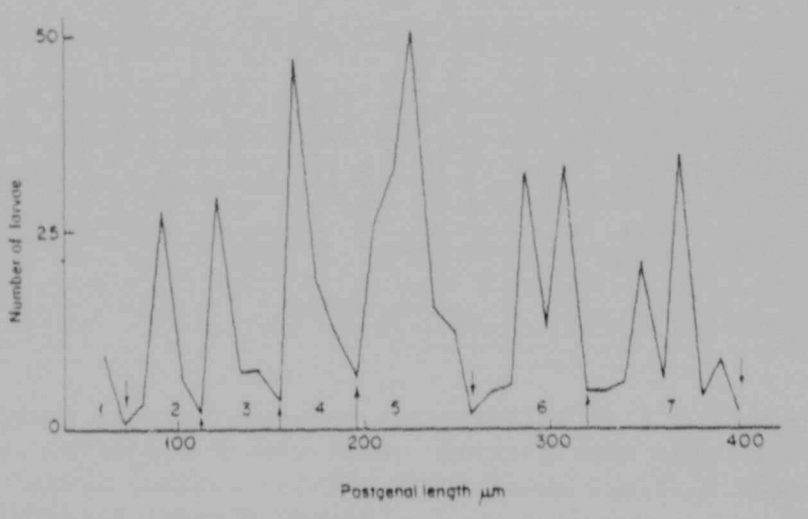

FIGURE 19: Postgenal length frequency distribution of 481 *S. chutteri* larvae collected 8 March 1979. Arrows show the limits of each instar

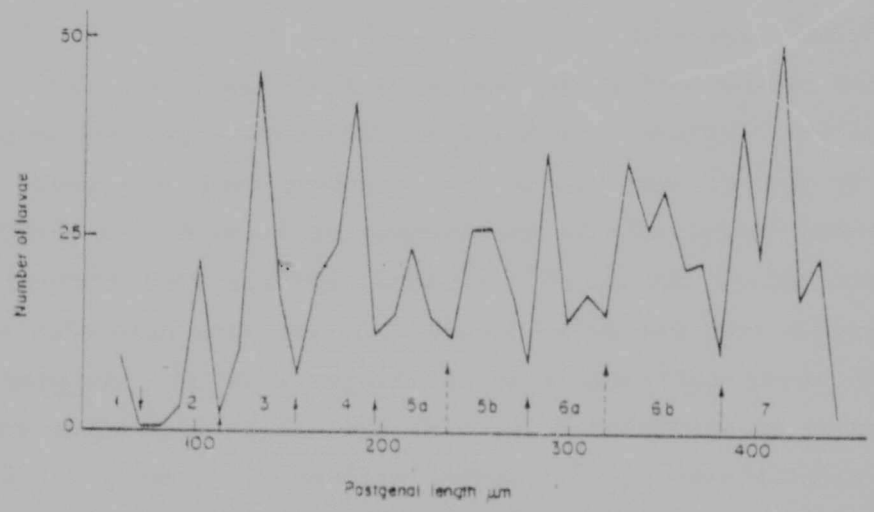

FIGURE 20: Postgenal length frequency distribution of 747 *S. chutteri* larvae collected 7 June 1979. Solid arrows show defined limits of each instar. Broken arrows show limits of apparent intermediate instars

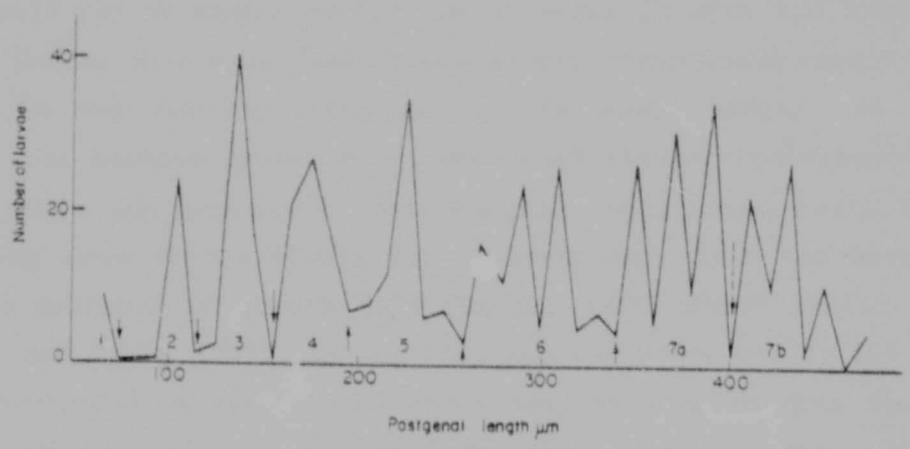

FIGURE 21: Postgenal length frequency distribution of 516 *S. chutteri* larvae collected 5 July 1979. Solid arrows show limits of each larval instar. Broken arrow shows limit of apparent intermediate seventh instar

Simpson *et al.* (1963) stated that, if the geometric growth rate (*Kg*) remained constant throughout the larval life, then growth (or instar) measurements would fit a perfect exponential regression curve. This is however seldom the case for biological data. For populations in which there were clearly seven separable larval instars (Figs 18 and 19) *Kg*

values were fairly steady between instars two and six but were obviously high between the first and second, and low between the sixth and seventh instars (Table 5). Irrespective of the subsequent apparent number of instars, growth from the first to the second instar was always rather high from the calculated *Kg* values (Tables 5 and 6). Crosby's ratio for instars one to three was also greater than 10 per cent in six of the seven samples (Table 7). A critical examination of the actual measurements helps to explain this apparent anomaly. First and second instar larvae have very pale head capsules with poorly delimited post-occipital and hypostomal margins. At 50 x magnification a measuring error of up to 0,5 micrometer units is possible and this would introduce an error of approximately 10 to 11 µm . In smaller larvae this is considerable and if taken into account for the first and second instars then Crosby's ratio for all the above cases would drop to below 10 per cent.

Due to energy consuming processes such as an increased silk production and preparation for pupation and ensuing metamorphosis in the final instar, which is for the latter part of its existence a pharate pupa (Hinton, 1958), a large amount of the food assimilated by the penultimate instar would not be channeled into an increase in size and hence a smaller final instar than predicted from a growth curve would result. A slowing down in the feeding rates during the sixth instar, or the attainment of the maximum genetically controlled size of individuals of the species, under the prevalent environmental conditions, could also cause a slowing down of the growth rate between the sixth and seventh instars. This decrease in growth rate for the last larval instar was noted by Ross and Craig (1979) in the USA, and was borne out by the fit of data to exponential curves for all seven samples used in this study. An example is given in Figure 22 where the data point for the seventh instar lies well below the constructed growth curve.

Special circumstances therefore account for the abnormal geometric growth ratio between the first and second and sixth and seventh instars, and it may be concluded that for September 1977, September 1979 and December and March 1979 (Figs 18 and 19, Table 5) analysis of the growth rate constant supports the size frequency based conclusion that there are seven larval instars. The mean sizes of instars were all significantly different from each other ($p < 0,001$).

TABLE 5: Mean postgenal lengths (micrometres) and geometric growth rates (*Kg*) of *S. chutteri* larvae collected 11 September 1977, 7 December 1978, 8 March 1979, 13 September 1979

Dates	11 September 1977				7 December 1978				8 March 1979				13 September 1979			
Instars	No.	Mean	S.D.	*Kg*	No.	Mean	S.D.	*Kg*	No.	Mean	S.D.	*Kg*	No.	Mean	S.D.	*Kg*
1	34	62,12	2,46		10	61,50	0,00		9	61,50	0,00		12	61,50	0,00	
				0,50				0,41				0,41				0,51
2	76	102,50	8,20		22	92,66	2,26		36	93,07	5,13		48	102,50	0,00	
				0,33				0,29				0,32				0,34
3	82	142,48	8,41		59	123,62	6,97		44	127,72	8,20		174	144,53	5,95	
				0,33				0,31				0,28				0,33
4	115	197,42	15,17		59	167,90	9,02		81	169,13	8,20		166	201,31	11,07	
				0,31				0,27				0,27				0,27
5	206	268,35	20,09		54	220,79	12,92		141	220,99	12,92		80	264,66	17,22	
				0,25				0,31				0,29				0,23
6	267	344,40	13,74		167	300,12	17,63		91	295,41	13,33		88	334,15	15,58	
				0,18				0,20				0,20				0,21
7	236	414,10	15,17		307	365,11	13,12		79	362,03	16,40		84	410,62	14,76	

TABLE 6: Mean postgenal lengths (micrometres) and geometric growth rates (*Kg*) of *S. chutteri* larvae collected 8 June 1977, 7 June 1979, 5 July 1979

Dates	8 June 1977				7 June 1979					5 July 1979			
Instars	No.	Mean	S.D.	*Kg*	Instars	No.	Mean	S.D.	*Kg*	Instars	No.	Mean	S.D.	*Kg*
1	43	61,71	2,67		1	9	61,50	0,00		1	9	61,50	0,00	
				0,49					0,51					0,51
2	15	101,07	7,59		2	27	102,09	4,51		2	25	102,91	2,05	
				0,30					0,29					0,28
3	51	136,94	8,61		3	81	136,12	8,20		3	59	135,92	5,33	
				0,29					0,27					0,26
4	88	182,66	14,76		4	98	178,97	9,84		4	72	175,69	9,84	
				0,30					0,29					0,25
5	151	245,80	17,22		5	146	240.26	21,94		5	70	225,71	12,71	
				0,28					0,31					0,27
6	354	324,72	29,93		6	223	328,00	26,45		6	98	295,00	20,30	
				0,26					0,21					0,29
7	174	422,92	21,32		7	163	406,11	15,58		7	183	394,83	32,60	
6a	165	297,25	13,12		5a	66	218,94	10,66		7a	108	371,46	16,20	
				0,16					0,16					0,14
6b	189	348,71	17,02		5b	80	257,69	10,25		7b	75	428,45	17,02	
					6a	68	294,59	8,82	0,13					
					6b	155	342,76	16,20	0,15					

5a & b, 6a & b and 7a & b in each case represent the 5th, 6th or 7th instar divided into two disctinct size classes (see also text and Figures 20 and 21)

TABLE 7: Comparison of Crosby's ratios expressed as the percentage change between two consecutive Brook's ratios for samples collected at various dates

	Crosby's ratios %						
Date of samples	8 Jun 1977	11 Sept 1977	7 Dec 1978	8 Mar 1979	7 Jun 1979	5 Jul 1979	13 Sept 1979
Comparing instar							
1 2 3	-17,27	-15,76	-11,46	-9,32	-19,68	-21,07	-15,40
2 3 4	-1,55	-0,32	1,81	-3,51	-1,39	-2,14	-1,21
3 4 5	0,88	-1,90	-3,18	-1,33	2,11	-0,61	-5,61
4 5 6	-1,83	-5,58	3,37	2,31	1,69	1,74	-3,96
5 6 7	-1,42	-6,31	-10,51	-8,33	-9,31	2,40	-2,68

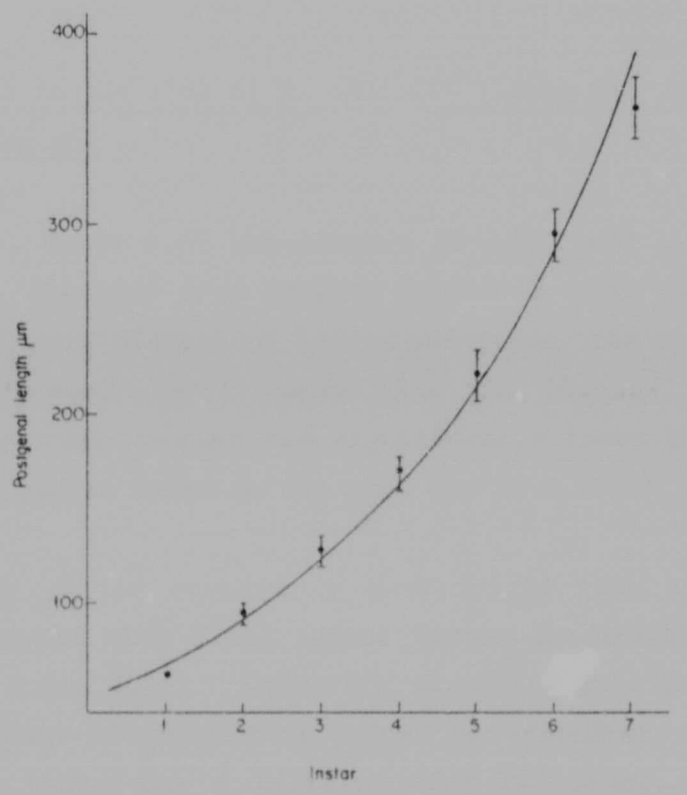

FIGURE 22: Mean lengths of postgena of the seven larval instars of *S. chutteri* collected 8 March 1979. Vertical bars indicate standard deviation for each value. Regression line plotted $Y = 50,36e^{0,29x}$, $r^2 = 0,99$

From Table 6 and Figure 21 it is apparent that there could be eight instars in June 1977 and July 1979 where the sixth and seventh instars are respectively divided into two 'instars' (6a and b for June 1977 and 7a and b for July 1979). In June 1979 (Table 6, Fig. 20) both the fifth and sixth instars are each further divided up into two instars (5a and b, 6a and b). Calculated *Kg* values (Table 6) for these apparent additional instars indicate an inexplicable drop in growth rates between the fourth and eight or ninth instars.

The data, if calculated to represent eight or nine instars, did not fit an exponential growth curve with the same coefficient of determination as the data for seven instars. For eight or nine instars the best fit curves were linear regressions which is inconsistent with a geometric growth function (Simpson *et al.*, 1963). From this it could be concluded that there were not extra larval instars present at these times but that individuals belonging to certain instars fell into two separable size groups.

6.3.2 Variation in the size of *S. chutteri* larvae and pupae due to season and sex

In Appendix 2.5, Table 2.21 the biomass of 100 final instar larvae and 100 pupae of *S. chutteri* from samples collected over several dates is given. Comparing the biomass of larvae and pupae, the paired t statistic test (Hewlett Packard, 1976) showed that the biomass of *S. chutteri* pupae including their cocoons was significantly lower than the biomass of final instar larvae taken on the same day (t = 10,17, p <0,001).

Over the entire period covered, a mean weight loss of approximately 25 per cent occurred when final instar larvae metamorphosed into pupae (Appendix 2.5, Table 2.21). Comparing the difference in biomass of 100 final instar larvae or pupae from August to September with those from March to April using the t statistic for two means, values for the larvae of t = 8,48 (p <0,001) and pupae t = 10,06 (p <0,001) were obtained The biomass of 100 larvae or pupae in late winter and spring was more than double that in summer.

Population density did not appear to play a role in the determination of the mean size of larval semaphoronts. Population estimates from stones-in-current samples from September 1977 and September 1979, when water temperatures were similar (18,0 and 17,2 °C), were 9 697 and 6 709 larvae per 1 000 cm^2 respectively. In December 1978 and March 1979, when water temperatures were again similar 29,0 and 28,6 °C), the population densities were 8 099 and 306 per 1 000 cm^2 of stone surface area respectively. Whereas the densities of larvae in September 1977 and 1979 were similar, the density of larvae in December 1978 was almost twenty seven times greater than that in March 1979, yet for both sets of data the sizes of larval semaphoronts were similar (Table 5). Day length (photoperiod) also seems less important than temperature in both pupal life cycle duration (Table 29) and size determination of larvae, where day length calculated for December 1978 and March 1979 was 13h50 and 12h12 respectively (Kahoun, 1978) but larvae were seen to be of similar sizes (Table 5). Water discharge fluctuated considerably during the period when size variations of the larvae of Simuliidae were studied (Ch. 4, Fig. 8) and could also not account for variations in size of individuals at different times of the year. Fluctuations in the pH of

TABLE 8: Distance (micrometres) from base of respiratory histoblast to tip of wing in *S. chutteri* pupae and comparisons of the mean sizes of males and females using the *t* test

Date	Male pupae			Female pupae			
	No.	Mean	Standard deviation	No.	Mean	Standard deviation	Student's *t*
8 March 1979	24	1371,60	58,40	19	1442,00	55,60	4,03*
7 June 1979	32	1558,80	64,00	30	1621,20	78,40	3,42**
21 June 1979	34	1616,40	68,40	39	1689,20	63,20	4,70*
5 July 1979	30	1694,80	44,40	30	1775,20	55,60	6,10*
13 September 1979	40	1603,20	58,40	35	1702,80	74,80	6,36*
9 October 1979	29	1434,40	57,20	31	1498,00	52,40	4,48*
6 December 1979	40	1313,20	55,20	40	1351,20	56,00	3,06§

Difference: * Significant at the 0,001 level ** Significant at the 0,002 level
§ Significant at the 0,005 level

TABLE 9: Body lengths (micrometres) of larval instars, selected on postgenal length measurements, compared with head capsule pigmentation (larvae collected September 1979)

Instar	Mean postgenal length µm	S.D.	Body length of larvae with white head capsules			Body length of larvae with yellow head capsules			Body length of larvae with brown head capsules		
			No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
3	143,50	4,72	3	1085,00	0,00	13	1138,48	131,75	4	1085,00	126,33
4	202,13	6,56	6	1511,25	323,95	8	1685,63	226,30	8	1656,95	244,90
5	267,94	14,97	4	2015,00	126,33	10	2301,75	228,63	6	2325,00	213,90
6	332,72	17,02	8	2848,13	300,70	8	3371,25	336,35	4	3313,13	324,73
7	408,57	13,53	7	4063,33	493,68	10	5053,00	320,08	4	5502,50	227,85

the river water between December 1978 and April 1980 were minor and were also not considered to account for larval size variation (Appendix 2.7, Table 2.24).

Measurements of male and female pupae (Table 8) indicate that the mean sizes of females were significantly larger ($p < 0,005$) for the period covered. This would indicate that the multiple peaks sometimes discernible within some of the later larval stages (Figs 18, 19 and 20), where the separation of instars was clear, were due to sexual dimorphism.

Comparison of the mean larval body sizes for larvae with similar head capsule sizes but differing in levels of pigmentation indicated that there was a significant difference between the larval body sizes ($p < 0,02$) of instars with white, and yellow or brown pigmented head capsules for the 5th, 6th and 7th instars (Table 9). This would indicate that when a larva moults from one instar to the next its body size, which attained a maximum size for the earlier instar, now appears relatively small for the new instar. As this new larva feeds, its body gets larger but the head capsule remains the same size turning from a pale white through a yellow to a brownish pigmentation before moulting once more into the next instar.

TABLE 10: Width of postoccipital gap (micrometres) in head capsules of *S. chutteri* larvae

Instar	No.	Range µm	Mean µm	Standard deviation
(a)	Larvae collected 13 September 1979			
1	5	2 - 4	2,46	0,92
2	5	8 - 10	9,02	1,12
3	5	16 - 21	18,04	2,25
4	10	25 - 31	30,14	1,94
5	10	41 - 51	47,15	5,29
6	10	82 - 103	90,20	10,59
7	10	205 - 267	234,73	18,37
(b)	Larvae collected 7 June 1979			
4	6	21 - 31	22,21	4,18
5	15	41 - 62	49,88	9,38
6	15	82 - 134	103,87	11,54
7	10	225 - 267	236,78	14,05

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The width of the postoccipital gap approximately doubled between instars (Table 10). When the larval instar sizes extended over a greater range (June 1979) the postoccipital gap still doubled in size between instars but the size range of the gap was now also somewhat extended (Table 10b).

6.3.3 Criteria useful in separating instars of *S. chutteri*

Though sizes of larval semaphoronts may vary at different times of the year, and overlap of different sizes of larvae occurs in winter it is clear from the above discussion that *S. chutteri* goes through seven larval instars in its development through to pupation. The following guide to identify the seven instars of *S. chutteri* has been drawn up.

Select final instar larvae from a sample of larvae collected on one date, i.e. those with darkened respiratory histoblasts or with separated cervical sclerites. Measure the postgenal lengths of about 40 or 50 of these larvae and determine the mean. If the mean length is less than 380 µm they fall into the *small* category. If greater than 390 µm they belong to the *large* category.

i) Egg burster always present, postgenal length of head capsule less than 75 µm; postoccipital gap 2 - 4 µm ..... FIRST INSTAR

ii) No egg burster, postgenal length of head capsule 80 - 110 µm *small*; 90 - 120 µm *large* ; postoccipital gap 8 - 10 µm ..... SECOND INSTAR

iii) Postgenal length of head capsule 115 - 140 µm *small*; 120 - 160 µm *large*; postoccipital gap 16 - 21 µm ..... THIRD INSTAR

iv) Postgenal length of head capsule, 150 - 185 µm *small*; 160 - 200 µm *large*; postoccipital gap 21 - 35 µm ..... FOURTH INSTAR

v) Postgenal length of head capsule 190 - 250 µm *small*; 210 - 300 µm *large*; postoccipital gap 40 - 62 µm ..... FIFTH INSTAR

vi) Cervical sclerites visible but joined to postocciput, postgenal length of head capsule 260 - 330 µm *small*; 270 - 350 µm *large*; postoccipital gap 80 - 134 µm ..... SIXTH INSTAR

vii) Cervical sclerites separated from postocciput, postgenal lengh of head capsule 330 - 400 µm *small*; 370 - 490 µm *large*; postoccipital gap 200 - 270 µm ..... SEVENTH INSTAR

6.3.4 The seasonal variation in the duration of the various developmental stages in *S. chutteri*

a) The egg stage

Well-developed simuliid eggs were often encountered in drift samples and occasionally first instar larvae were seen in the process of natching. Eggs collected from the drift were usually in various stages of development and hatching was often seen to occur within one day of collection. Eggs placed in small petri dishes also hatched within five days. Larvae kept in water which was not aerated with an airstone died within four days. Laboratory observations on eggs collected from the drift could not be used to determine the duration of the egg state from laying to hatching but did indicate that *Simulium* eggs found drifting in river water were viable.

An idea of the duration of the egg stage was obtained from data gathered from a daily study of drift in the late afternoon carried out over a period of sixteen days from 13 to 28 September 1979 (Appendix 2.2.7). From Figure 2.3 in this Appendix it is apparent that a peak in the numbers of eggs found in the drift is sometimes followed a day later by a peak of first instar larvae. Quite often however these peaks are seen to coincide. This may indicate that the duration of the egg stage, from the time of its appearance in the drift, was less than one day at that time of the year. Peaks of other larvae, mostly second and some third instars, occurred about two to three days after peaks of eggs or first instars were encountered.

b) The larval stages

Some of the shortcomings in using larvae, collected from natural stones-in-current samples, for determining the duration of larval development were outlined on Page 67. The data were nevertheless analysed and are presented in Table 11.

From Table 11 it is clear that the percentage of smaller-sized larvae were higher and of the larger larvae and pupae lower on stone 4 than on the other stones.

A chi-squared test carried out on the percentages of the larvae and pupae in Table 11 showed that the size frequency distribution of the simuliid population on stone 4 was significantly different to that on the other stones ($p < 0,05$). It can be concluded that on average the size frequency distribution of larvae is fairly similar from stone to stone (i.e. stones 1, 2, 3 and 5; Table 11) but that occasionally there are stones which have a greater abundance of smaller or larger larvae.

TABLE 11: The percentage of larvae and pupae and the total number of Simuliidae found on five stone samples collected at Witrand on 11 September 1977

Instar stage	Stone numbers				
	1	2	3	4	5
	Percentages				
1	3	4	3	5	3
2	8	6	8	11	8
3	7	6	6	15	7
4	9	11	8	18	10
5	14	12	17	15	11
6	18	21	21	12	18
7	21	24	19	16	21
Pupae	20	15	18	8	22
Total no. Simuliidae	12658	11051	12029	22893	9809

A size frequency analysis of the percentage of larvae and pupae found on natural stones-in-current from the 22nd July till the 11th September 1977 was carried out and the results are presented in Figure 23.

As samples were collected at four day intervals it was not possible to follow the development of any single cohort of a particular larval instar and therefore small larvae (first to fourth instars) were lumped together. The fifth and sixth instars were also presented as a single cohort but seventh instar larvae and pupae were presented as separate cohorts.

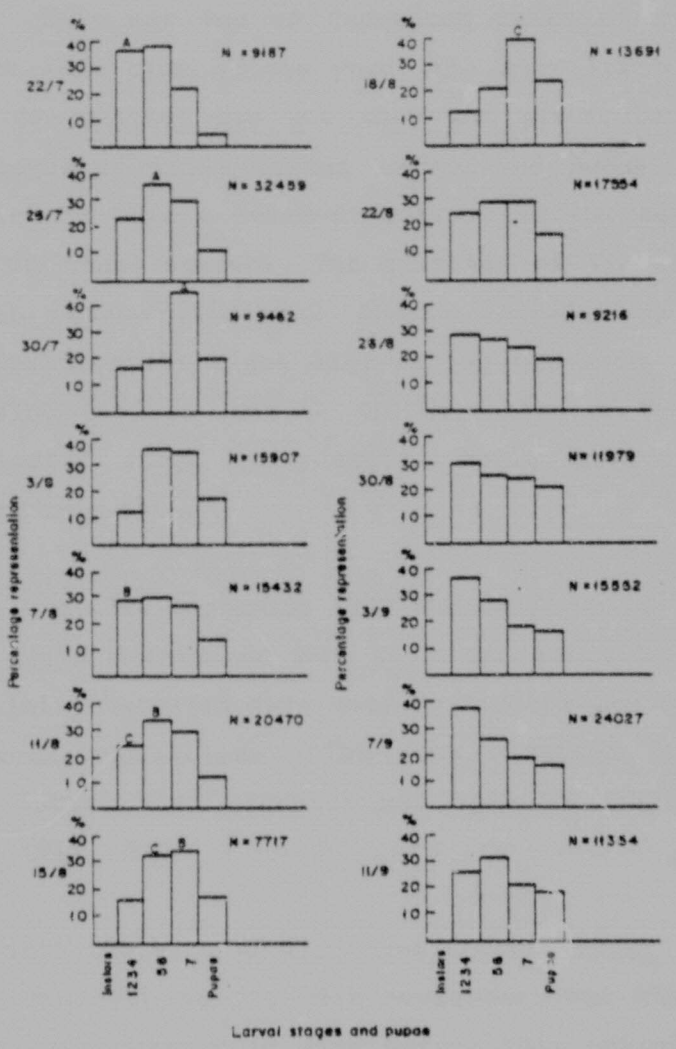


FIGURE 23 Percentage frequency of larval stages and pupae of Simuliidae collected from stones between 22 July and 11 September 1977. Combining instars 1, 2, 3, 4, instars 5, 6 and showing instar 7 separately. The estimated number of individuals on each stone is indicated on the right side of the histograms. Letters A, B and C above histograms follow the observed development of a group of larvae to the next stage with time

Figure 23 shows peaks in the abundance of small larvae on the 22nd July, 7 and 11 August and from the 22nd August onwards. Peaks of final instar larval abundance occurred on the 30th July and again on the 15th and 18th August, that is about eight days after small larvae were abundant.

In cohorts A, B and C in Figure 23 a peak abundance of medium-sized larvae (fifth and sixth instars) occurred about four days after the peak abundance of small larvae. This trend of a cohort of small larvae following through into cohorts of medium larvae and final instars at four day intervals continued until about 22 August. After that date there was always a higher percentage of smaller larvae present. This was due to increased rates of recruitment which occurred at this time of the year (Ch. 4). Further cohorts of larval size frequencies did not show any particular pattern. The high percentages of final instar larvae and pupae throughout this period indicated that a large proportion of the aquatic life cycle was spent in these stages. The duration of the larval life cycle from small larvae (first to fourth instars) up to final instars takes approximately eight days during the late winter and early spring period (end of July to mid September). The duration of the final instar stage to pupation could however not be ascertained from these data.

From the 17th to the 28th September 1979 the duration of the larval life cycle was again determined but in these and all subsequent studies artificial substrates were used to monitor the composition of simuliid larval populations. The data obtained from length measurements of larval head capsules was used to construct size frequency graphs (Fig. 24).

Figure 24 shows that the size of first and second instar larvae did not change from the 17th to the 28th September, but the third to fifth instar larvae decreased in size during this period. On the 19th September a multiple peak of size frequencies occurred where the fifth and sixth instars were expected, and on the 22nd September two double peaks occurred where the fifth and sixth instars should be situated. The decrease in size of the various instars during this period is recorded in Table 12.

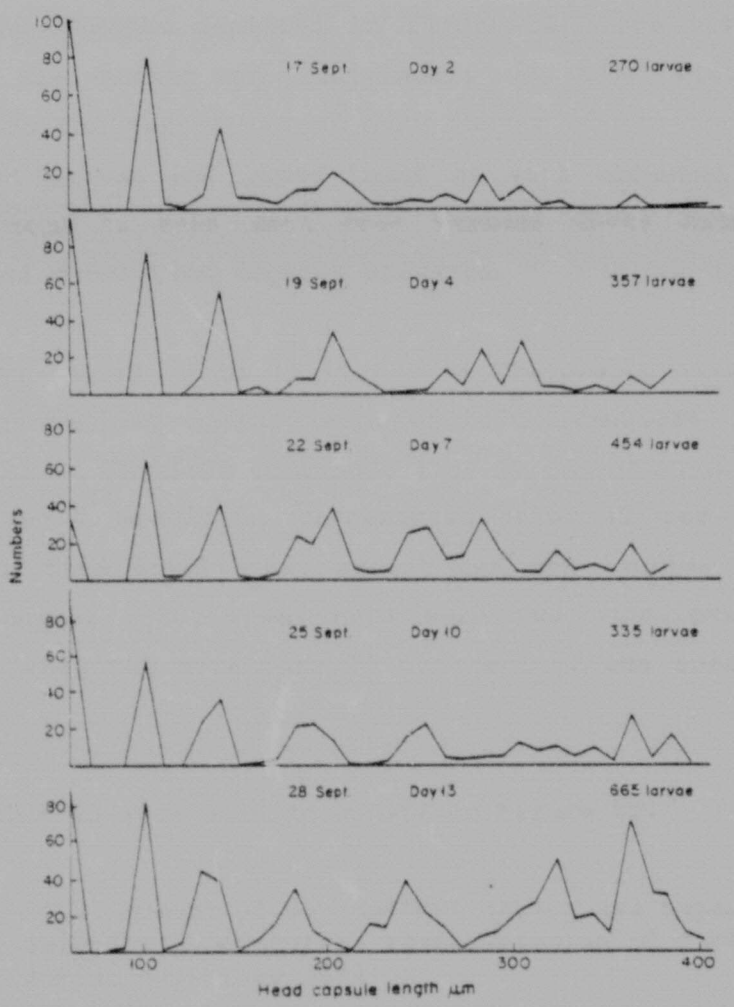
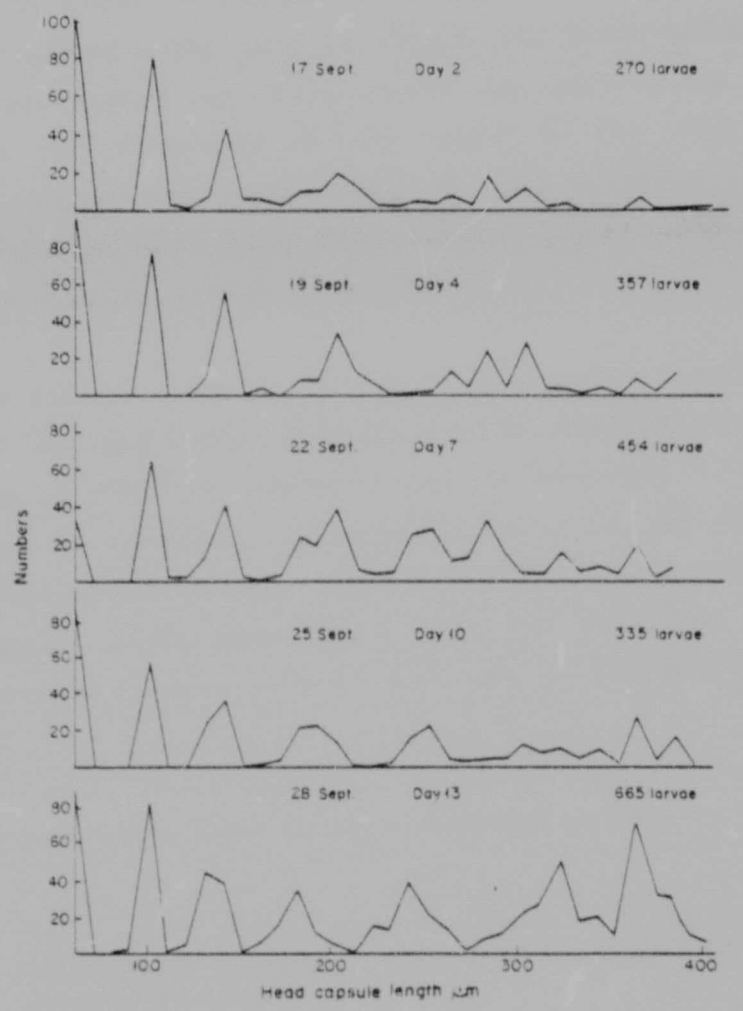


FIGURE 24: Size frequency distribution of *S. chutteri* larvae collected on artificial substrates from 17 to 28 September 1979. The number of larvae measured on each date are recorded on the right side of the graphs

TABLE 12: Head capsule measurements (HCL) of third to seventh instar *S. chutteri* larvae during September 1979

Instar	HCL size µm on 17 September	HCL size µm on 28 September
3	144 - 154	133 - 144
4	174 - 236	164 - 215
5	236 - 297	215 - 267
6	297 - 369	287 - 349
7	379 upwards	358 upwards



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