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Interim results of the Yoshino River productivity survey, especially on benthic animals*

The Yoshino River Team has been studying the communities of the Yoshino River, on the purpose to discuss finally the productivity of that river. Only a short summary of the benthic animal studies is reported in the paper.

1. INTRODUCTION

The Yoshino River (Fig. 1) is situated in Nara Prefecture, Central Japan, about 70 km in length, with clear, soft water; it does not freeze over winter. The area studied is the upper reaches as well as the tributaries of the river, where we find very rich aquatic insect fauna. No pollution, artificial dam or reservoir exist at present, although at least two dams will be constructed in near future.

Fish, benthic animals, algae, etc., were studied in the area. Only a short summary of the benthic animal studies will be reported here.

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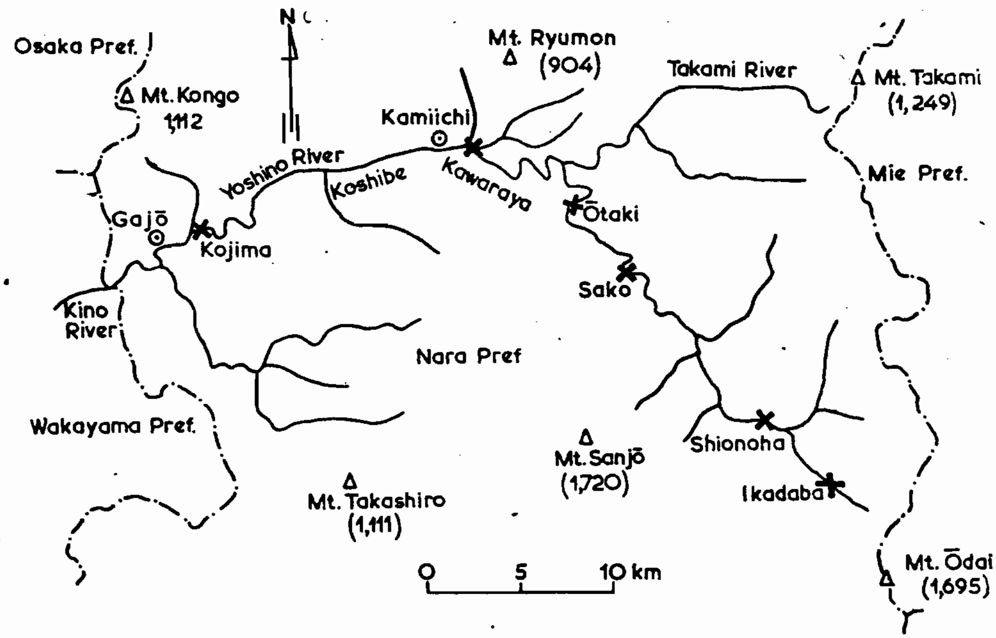

Fig. 1. Map of the Yoshino River, showing the stations studied

2. STANDING CROPS AND LONG TERM SUCCESSION

Standing crops of benthic animals (for the most part — aquatic insects) were studied at least four times in a year and in some stations monthly. Samples were taken by a 50 cm quadrat. At the stable, climax phase net spinning life forms are dominant, and especially the Stenopsychidae, which in riffles occupy very often more than 70% of the insect standing crop (T s u d a 1959, 1961, 1962).

The aquatic insect communities of the Yoshino River are now almost at their climax phase. After the "Isewan Typhoon" (September, 1959), the river bed was catastrophically disturbed and the benthic communities were destroyed completely. The river bed has recovered gradually during the lapse of 10 years and the communities as well. Diversity of species increased, dominant species changed with the lapse of the time. The dominant forms changed from creeping form (Ephemeroptera, etc.) to *Hydropsyche* and then to Stenopsychidae (T s u d a and K o m a t s u 1964, G o s e 1968). This river now has a Stenopsychidae-dominant community. Standing crop increased with sigmoid curve. Examples are given in Figure 2, 3 and 4.

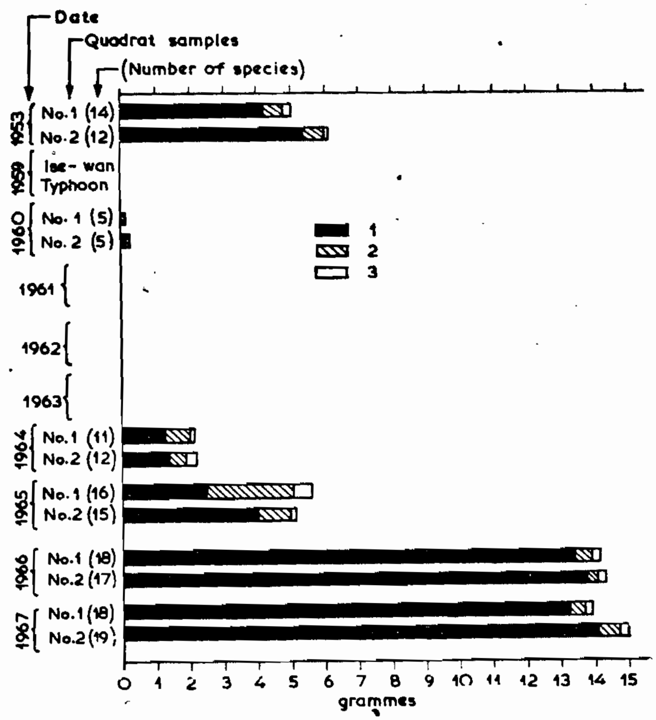

Fig. 2. Standing crop at the station Ikadaba [1953—1967; sum of two quadrat (50 × 50 cm) samples]
1 — net-spinning forms, *2* — creeping forms, *3* — others

3. LIFE HISTORIES OF AQUATIC INSECTS

Samples of Ephemeroptera, Plecoptera and Trichoptera were taken monthly from the stations Ikadaba and Anou, the body length was measured, also instars were determined (Trichoptera). The life history diagrams of many insects were constructed (Fig. 5—8) (Gose 1970b).

At station Ikadaba: *Ephemera japonica* McLachlan, *Ephemerella trispina* Véno, *E. yoshinoensis* Gose, *E. nigra* Véno, *Ameletus costalis* Matsumura, *Epeorus uenoi* Matsumura, *E. latifolium* Véno, *Ecdyonurus kibunensis* Imanishi, *E. yoshidae* Takahashi, *Paraleptophlebia spinosa* Véno (Ephemeroptera) and *Alloperla abdominalis* Okamoto (Plecoptera) have one generation per year, and *Stenopsyche griseipennis* McLachlan has 1.5 generations per year.

At station Anou with warmer water temperature than the Ikadaba station, the *Stenopsyche griseipennis* has two generations per year. At station Miyataki a chironomid, *Spaniotoma* sp. A, has 6 generations in a year (Fig. 9) (Kitagawa 1969).

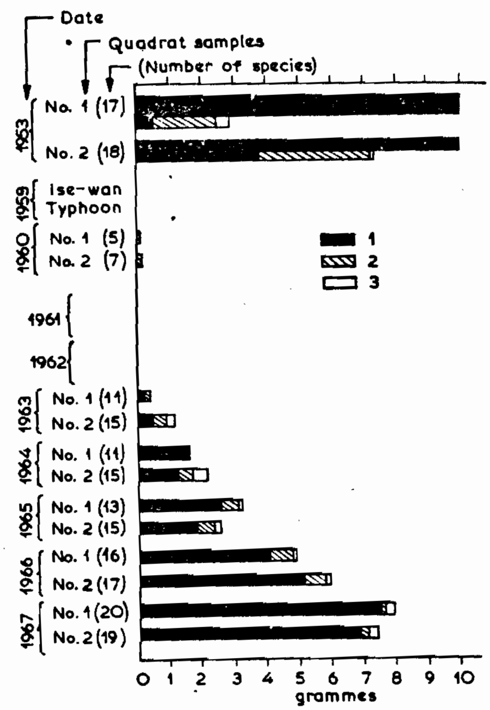

Fig. 3. Standing crop at the station Kawaraya [1953—1967; sum of two quadrat (50×50 cm) samples]

1 — net-spinning forms, *2* — creeping forms, *3* — others

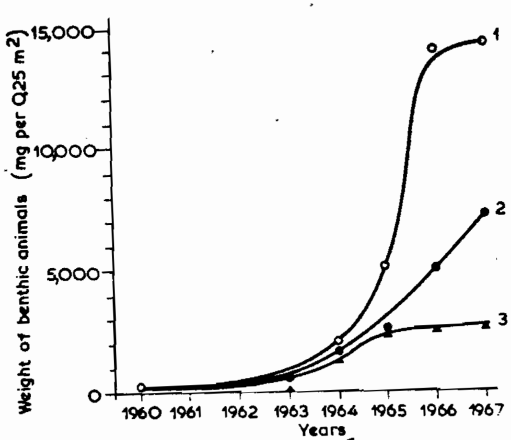

Fig. 4. Curves of the increases of the standing crops after the Ise-wan Typhoon

1 — Ikadaba *2* — Kawaraya, *3* — Ōtaki

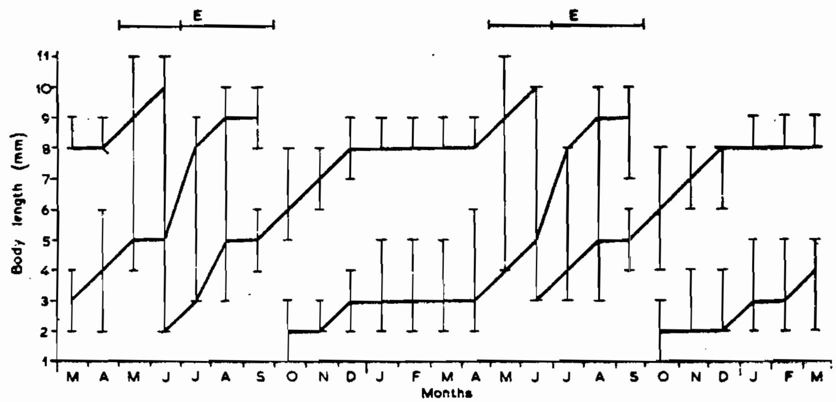

Fig. 5. Life history diagram of *Epeorus latifolium* at the station Ikadaba
E — emergence period. The mode and size range of nymphs are shown for each month

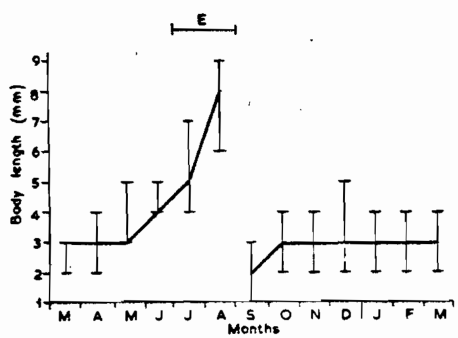

Fig. 6. Life history diagram of *Ecdyonurus yoshidae* at the station Ikadaba
E — emergence period

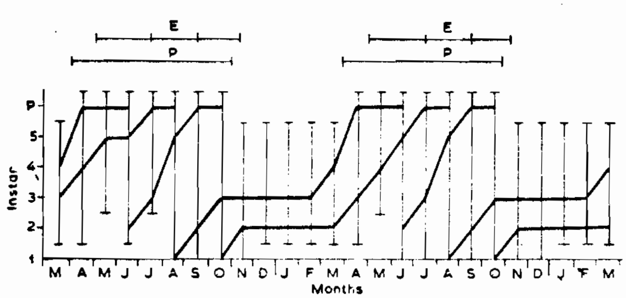

Fig. 7. Life history diagram of *Stenopsyche griseipennis* at the station Ikadaba
E — emergence period, *P* — pupal stage

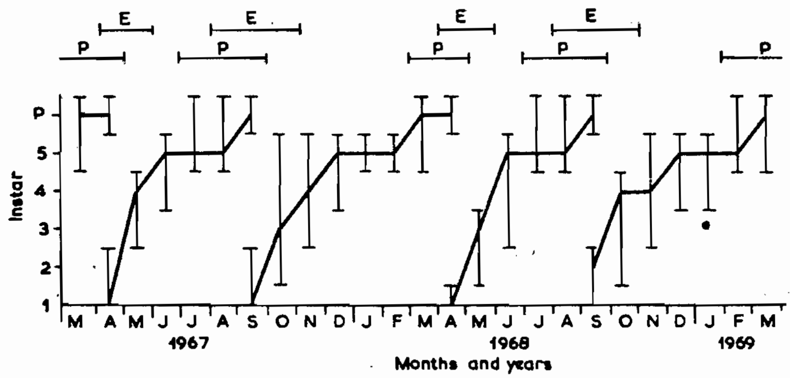

Fig. 8. Life history diagram of *Stenopsyche griseipennis* at the station Anou
E — emergence period, *P* — pupal stage

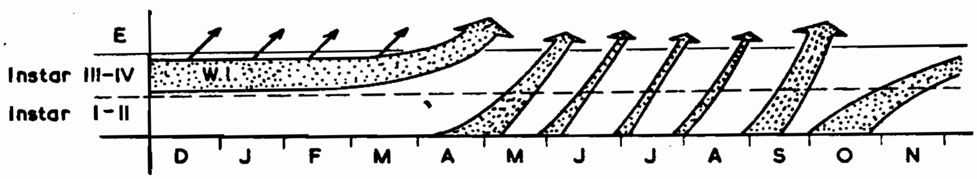

Fig. 9. Life cycle of *Spaniotoma* sp. A at the station Miyataki
W.I. — wintering larvae, *E* — emergence

4. PRODUCTION RATE

Production rate of univoltin *Ephemera strigata* Eaton in a pool of the station Anou, Niu-gawa was calculated (the samples were taken monthly) according to the formula proposed by Ricker (1946) and Allen (1949) — $B = K \times \overline{P}$ (where: B — production rate in g per m²/day, K — instantaneous rate of growth in g per g/day, $\bar{P}$ — mean population density in g per m²). Figure 10 shows that *E. strigata* is univoltin. The data are shown in Table I. Monthly change of individual number per 1 m² is shown in Figure 11, and monthly change of standing crop (weight) — in Figure 12. Figure 13 shows the growth curve based on the largest individuals found in samples of every month. On the basis of Figure 12 and 13 the production rate was calculated, of which values are again shown in Table I (two columns at the right). The production rate was found to be about 4.25 g/m² in a pool of the river. The yearly turnover rate is 2.4 (Gose 1970a).

Table I

Production rate of *Ephemera strigata* by the growth method

Period	Days	K (g/g day)	P (g/m^2)	Production rate (B) for day (g/m^2)	Production rate (B) for period (g/m^2)
May 15–June 15	31	0.1556	0.02	0.003	0.096
June 15–July 15	30	0.0469	0.04	0.002	0.056
July 15–Aug. 16	32	0.0467	0.30	0.014	0.448
Aug. 16–Sep. 15	30	0.0268	0.95	0.026	0.764
Sep. 15–Oct. 16	31	0.0110	1.53	0.017	0.521
Oct. 16–Nov. 17	32	0.0090	1.40	0.013	0.419
Nov. 17–Dec. 17	30	0.0091	2.01	0.018	0.549
Dec. 17–Jan. 18	32	0.0074	2.89	0.021	0.685
Jan. 18–Feb. 16	29	0.0017	2.62	0.005	0.130
Feb. 16–March 17	30	0.0019	2.44	0.005	0.141
March 17–April 17	31	0.0025	3.88	0.010	0.302
April 17–May 15	28	0.0013	3.74	0.005	0.137
Total annual production					4.248

K — instantaneous rate of growth, P — population density.

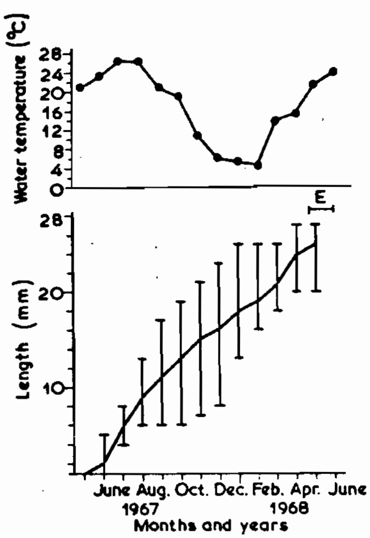

Fig. 10. Life history diagram of *Ephemera strigata*
E — emergence

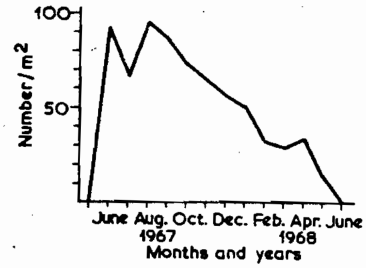

Fig. 11. Population density of *Ephemera strigata* in a pool

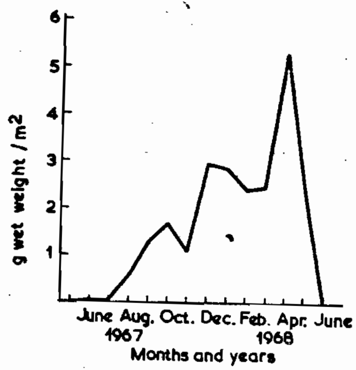

Fig. 12. Standing crop of *Ephemera strigata* in a pool

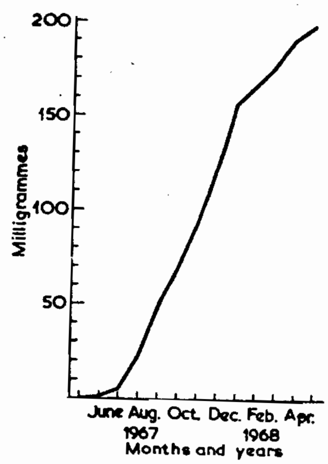

Fig. 13. Maximum weight of *Ephemera strigata* from which the growth rates were calculated

5. DRIFTS

Our drift-net is 50 cm width and 40 cm height at the mouth. The cloth net has a wire gauze plate of 1 mm mesh at the middle of the length, so that the drifted insects will be sorted in two size groups: the first group contains those which do not pass the 1 mm mesh, the second group which is caught at the end of the net-cloth contains only very small size ones.

According to the results taken on 3rd-4th August, 1968 (Fig. 14), Ephemeroptera were most abundant, followed by Trichoptera, Diptera and Plecoptera. Among Ephemeroptera, *Baëtis* spp. and *Baëtiella* spp. were very abundant, among Trichoptera — *Micrasema* sp., *Baëtis* and *Baëtiella* drift more at night than in the day, their peak being after the midnight. On the other hand, *Micrasema* drifts more in the afternoon. It is very interesting that the insect exuviae drift rather more in the afternoon than at other times (Okawara and Shiota 1970).

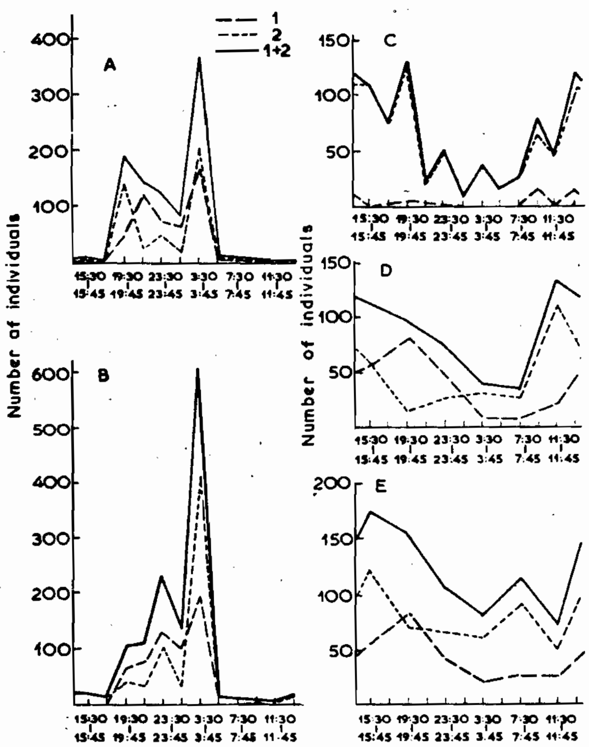

Fig. 14. Daily rhythm of some drifting insect larvae and drifting exuviae at the station Seto, Nakaoku-gawa, a tributary of the Yoshino River

A — ***Baëtis*** **spp. larvae,** *B* — ***Baëtiella*** **spp. larvae,** *C* — ***Micrasema quadriloba*** **larvae,** *D* — ***Baëtis*** **spp. exuviae** *E* — ***Baëtiella*** **spp. exuviae,** *1* — **larger sized individuals,** *2* — **smaller sized individuals**

Table II

Individual numbers of the drifting insects at the riffle up-stream of a pool (*A*) and those at the riffle directly down-stream of the same pool (*B*) (the figures mean the individual numbers caught in 15 minutes beginning at the time mentioned)

Insect groups	Dates and hours								Total	
	Dec. 13; 14 : 00		Dec. 13, 18 : 30		Dec. 14, 0 : 30		Dec. 14, 10 : 00			
	A	*B*	*A*	*B*	*A*	*B*	*A*	*B*	*A*	*B*
Ephemeroptera										
Ephemeridae	1		2	1	4	3			7	4
Leptophlebiidae	1	1	2	3	3				6	4
Ephemerellidae	4	2	11	5	5		1	2	21	9
Baëtidae	6		10	6	5	2	4	1	25	9
Siphlonuridae					2				2	
Ecdyonuridae	8	6	14	10	5	5		5	27	26
Total	20	9	39	25	24	10	5	8	88	52
Plecoptera										
Perlodidae	2			1				1	2	2
Perlidae	4	6		2	7	4	2		13	13
Total	6	6		3	7	4	2	1	15	15
Trichoptera										
Rhyacophilinae	2		1			1	1		4	1
Glossosomatinae	3	1	1	2	1				5	3
Stenopsychidae	2		2	1	1	2		3	5	6
Hydropsychidae	6	2	4	3	5	3	3	6	18	14
Total	13	3	8	6	7	6	4	9	32	24
Diptera										
Tipulidae	5	1	1	2			4	3	10	6
Simuliidae	2			1					2	1
Chironomidae	4	1	1		3			2	8	3
Total	11	2	2	3	3		4	5	20	10
Other insects	1		2		1		1		5	
Sum total	51	20	51	37	42	21	16	23	160	101

The amount of the drifting insects at the riffle directly down-stream of a pool is less than those at the riffle directly up-stream of the same pool (Okawara 1970). Table II gives the results of the study at Washikaguchi, Takami-gawa, a tributary of the Yoshino River: *A* — at the riffle up-stream of a pool, *B* — at the riffle directly down-stream of the same pool.

The number of the drift of some groups, i.e., Ephemerellidae and Baëtidae, is less at the point *B* than that at the point *A*. Therefore it suggests that rather large numbers of insects, which drifted down into the pool from the up-stream riffle might crawl up or swim again up-stream to the riffle. Nevertheless, it suggests also that many of the insects, which drifted into the pool, will migrate farther to the down-stream riffle. (The species listed in the Table II are mostly species of riffle origin and not from the pool.)

6. UP-STREAM MIGRATION

To verify how many insects will crawl up or swim up the stream, a trap as in Figure 15 was used.

The results given in Figure 16 shows that the upward migrating insects are more abundant during night than in the day (K. Gose — unpublished materials).

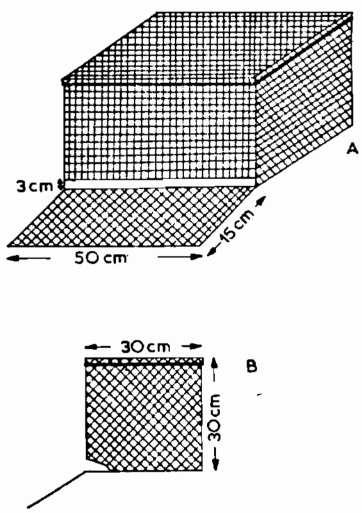

Fig. 15. Trap for the up-stream migrating aquatic insects
A — general view, *B* — lateral view

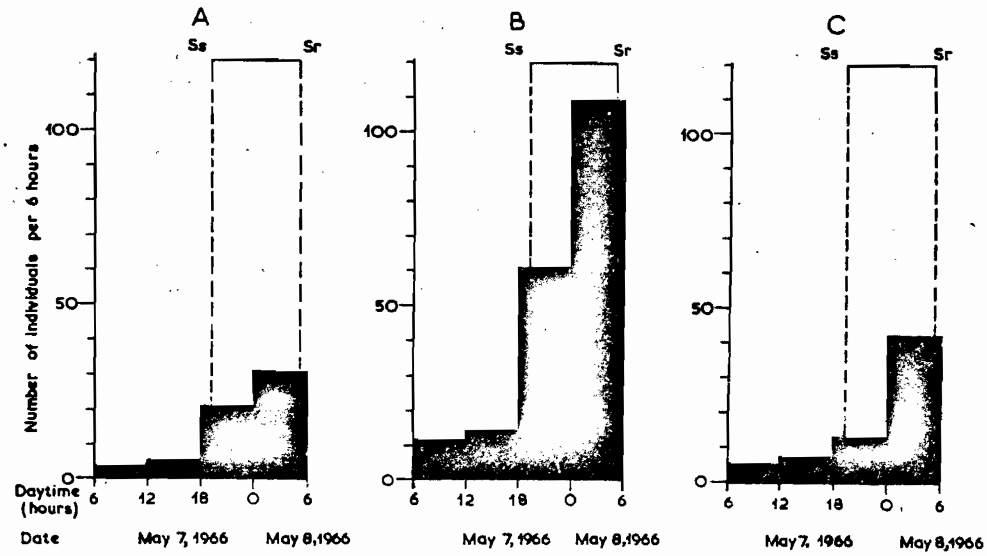

Fig. 16. Daily rhythm of the up-stream migration of the benthic animals

A — in the center of a rapid, *B* — near the side of the rapid, *C* — in the center of a relatively slower rapid, *Ss* — sunset, *Sr* — sunrise

7. SETTLING DOWN

To study how much the drifting insects will settle down in an area during a certain time, we used such device as follows: We take stones from the studied riffle, remove all insects attached to the stones and put those stones on a wire gauze of 50 × 50 cm area. This whole system is brought to the riffle and placed on the bottom. After 6, 24 or 48 hours the system is brought to the shore again and the insects newly settled down will be determined (Tetsukawa and Tarutani 1970). As for the results see Figure 17. It can be seen that Ephemeroptera settles down earlier and Trichoptera later.

I think the ratio:

$$\frac{\text{Individual number or weight of settled insect species per 24 hours}}{\text{Average individual number or average standing crop of a insect species in the riffle}}$$

may have some significance. And also the ratio:

$$\frac{\text{Amount of the settled insects per 24 hours}}{\text{Amount of the drifting insects per 24 hours}}$$

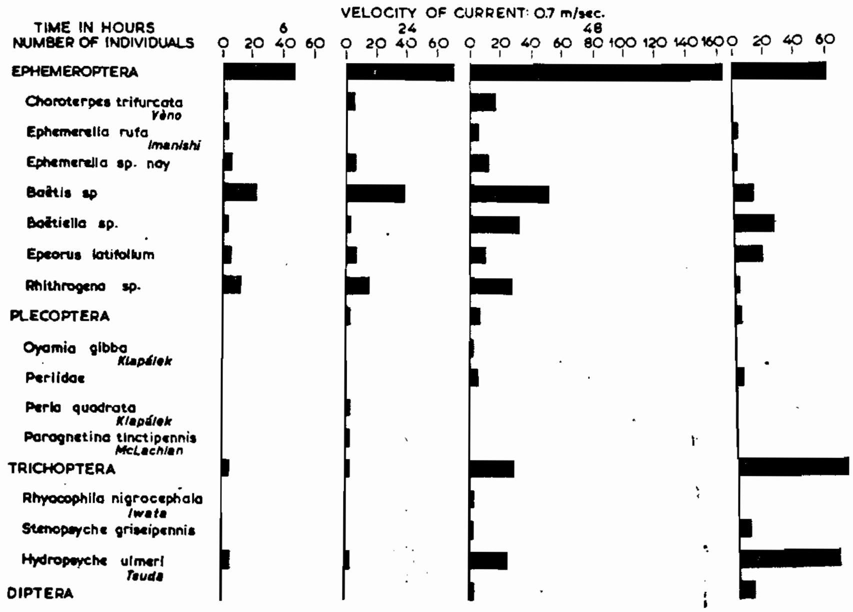

Fig. 17. Individual numbers of newly settled-down insects during 6, 24 and 48 hours (the column at the right end shows the average individual numbers per quadrat 50×50 cm at the riffle)

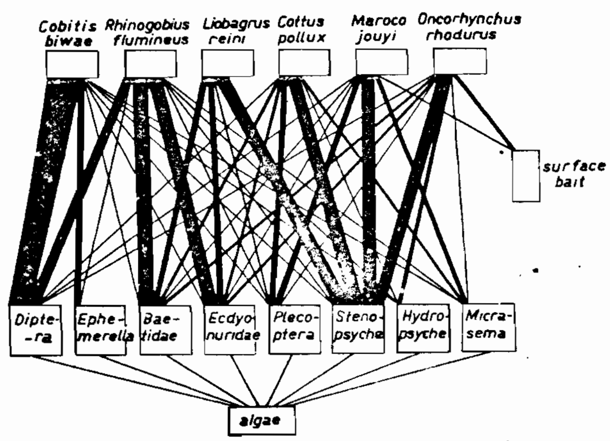

Fig. 18. Food relationships at the station Ikadaba

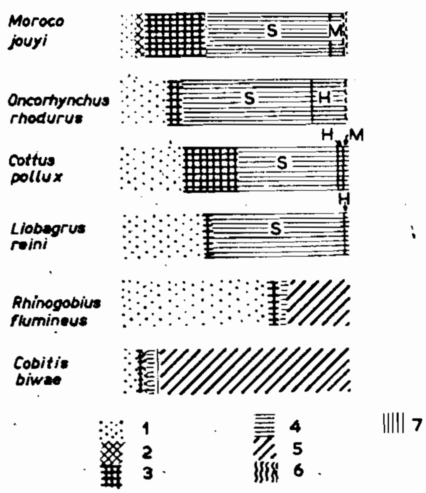

Fig. 19. Diagram of the food habit of the fishes, showing the ratio of the ingested organism groups
1 — Ephemeroptera, *2* — Odonata *3* — Plecoptera, *4* — Trichoptera, *5* — Diptera, *6* — imagines, *7* — algae, *S* — *Stenopsyche griseipennis*, *H* — *Hydropsyche ulmeri*, *M* — *Micrasema quadriloba* Martynov

8. FISH AND THEIR FOOD HABITS

The main fish species found in the area studied are: *Oncorhynchus rhodurus* Günther, *Moroco jouyi* Jordan et Snyder, *Cottus pollux* Günther, *Liobagrus reini* Hilgendorf, *Rhinogobius flumineus* Mizuno, *Cobitis biwae* Jordan et Snyder and *Plecoglossus altivelis* Temminck et Schlegel.

The last species, *P. altivelis* (Ayu in Japanese) is algophagous. The other fishes feed on aquatic insects. The food relation is shown in Figure 18, and the percentage of the food contents in Figure 19 (Tanabe 1970).

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