5.4 MACROINVERTEBRATES OF THE STONY BOTTOM
(by U.H. Humpesch, P.H. Anderwald, H. Petto)

5.4.1 Qualitative sampling

5.4.1.1 Fast bottom dredge (large)

The Fast bottom dredge (Fast 1986; Fig. 5.4.1 and Plate 5.4.1) is cylindrical (diameter 28 cm, length 123 cm), weighs 41 kg and is constructed from heavy-gauge, galvanised steel; therefore it can withstand abrasion and bumping on the bottom. As it is cylindrical, it will operate properly irrespective of its position on the bottom. Two towing eyes at the front allow the attachment of a bridle to pull the sampler. The funnel-shaped

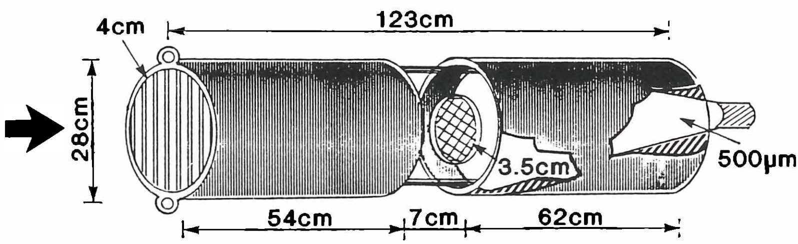


Fig. 5.4.1. General arrangement of the Fast bottom dredge. The arrow indicates the direction of the current.

mouth ingests and stirs up the bottom sediment, pebbles, stones etc., which enter the front tubular chamber. The mouth has bars that prevent large debris and stones from entering the sampler and the front and rear chambers of the sampler are separated by spacer bars. These allow small stones to fall out of the sampler, whilst lighter material drifts into the collection net in the rear chamber. The net (mesh aperture 500 μm) is 62 cm long with a metal collecting bucket at the rear and a mouth (diameter 17 cm) covered with very coarse netting to prevent the entry of large pieces of floating debris.

5.4.1.2 Some aspects of sampling strategies

The number of species or taxa taken in the samples usually increases as the size of the catch increases and the relationship often follows a power law (Fig. 5.4.2). As the number of species is therefore related to the size of the sample, a representative species list may be obtained by taking

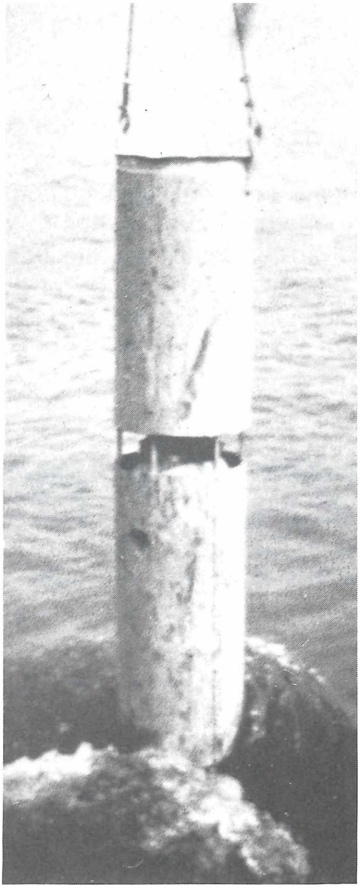


Plate 5.4.1. Fast bottom dredge after lifting.

many small sampling units or a few large units. Many small samples may be preferable in a heterogenous habitat because more widely spaced points may be sampled for the same total sample size. It is also difficult to compare the species richness or diversity of samples unless similar numbers of animals are taken in each sample.

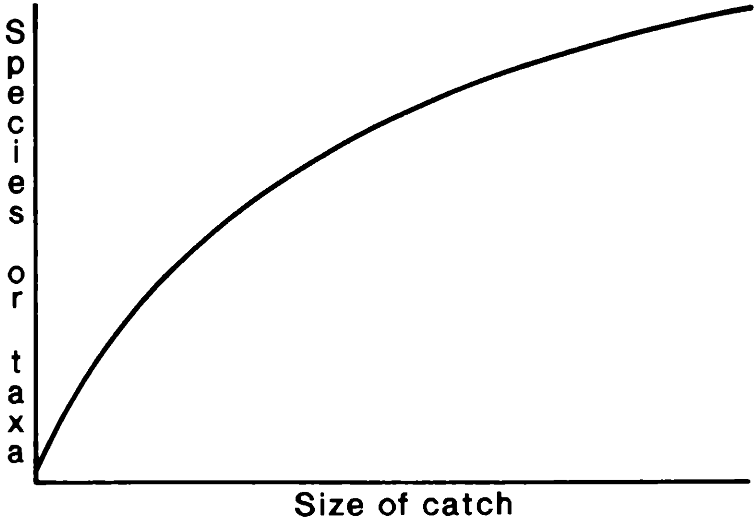


Fig. 5.4.2. Relationship between number of species or taxa and size of catch.

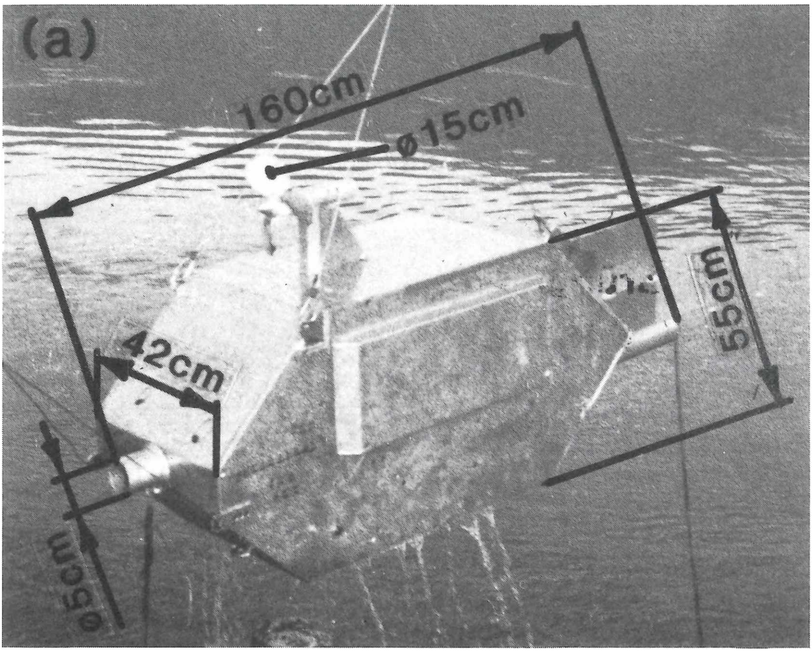


Plate 5.4.2. Automatic continuous drift sampler after lifting.

5.4.1.3 Automatic continuous drift sampler

The drift sampler is based on the marine continuous plankton sampler (Hardy, 1936), and was constructed by R. Niederreiter (Fig. 5.4.3). The sampler is 1.7 m long and has a width and height of about 0.5 m. The total weight is 80 kg. Sampling in the field requires a high powered motor boat for the exposure of the apparatus and a buoy to which the sampler can be fixed by means of a long rope. Because of its buoyancy, the sampler floats on the surface of the water and can be lowered to the desired depth by an anchoring weight and its rope.

5.4.1.3.1 General performance

The following sampling procedure was used (Fig. 5.4.3): The gauze band (S.b.), mesh size 400 μm, is steadily drawn through the water tunnel (W.t.), acting as a sieve that filters drifting organisms. After the sampling gap (S.g.) has been passed, the gauze band is covered by polyethylene foil (S.f.) and both tapes are stored in the preservation tank (P.t.), which contains formaldehyde solution. The polyethylene foil prevents trapped animals from being swept away from the gauze band after having passed the current-exposed sampling gap, and also separates single gauze

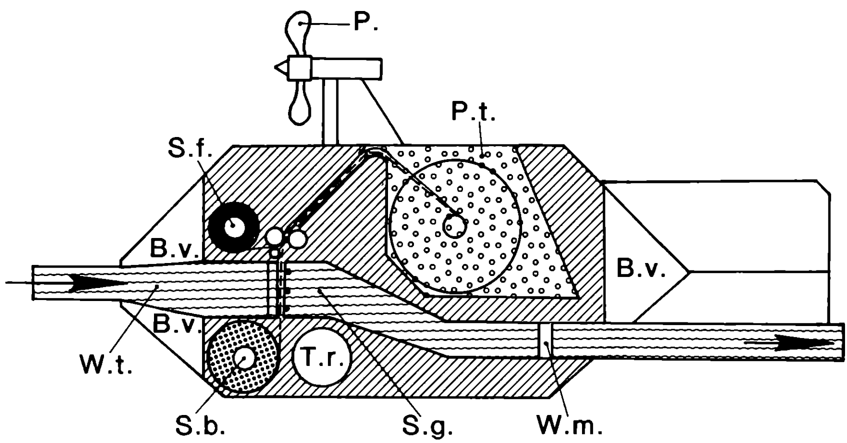


Fig. 5.4.3. Cross section of the continuous drift sampler. W.t. = water tunnel (arrow indicating the flow direction); S.g. = sampling gap; S.b. = spool containing gauze band; S.f. = spool containing polyethylene foil; P.t. = preservation tankfilled with formaldehyde (with storage spool); T.r. = time recorder; W.m. = water meter; P. = Propeller; B.v. = buoyancy volume.

band layers on the storage spool (P.t.). The whole device is driven by a propeller (P.), using the water current as an energy supply. Therefore the speed of the gauze band is proportional to the water velocity. The duration of a continuous sampling period is restricted to the total length of the gauze band, and the latter determines the whole dimensions of the sampler.
The gauze band is marked equidistantly, each marked length covering one sampling unit, and the time recorder (T.r.) notes the time required for the gauze band to pass the sampling gap from one mark to the next. Thus the marks can be related to a definite time interval and the sampling units can be timed. The total volume of water sampled is measured by a water meter (W.m.). Sampling units were obtained by washing out the gauze band, section by section, in the laboratory.

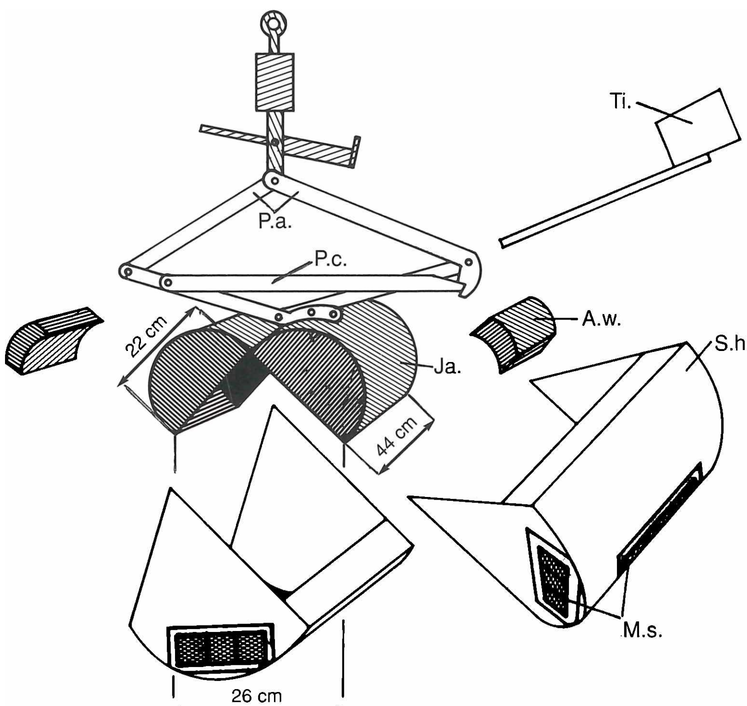


Fig. 5.4.4. General arrangement of the Petersen grab (modified by R. Niederreiter). P.a. = pivoted arms; P.c. = pivoted cross bar; Ja. = jaw; A.w. = additional weight; Ti = tiller; Sh = shovel; M.s. = metal screen.

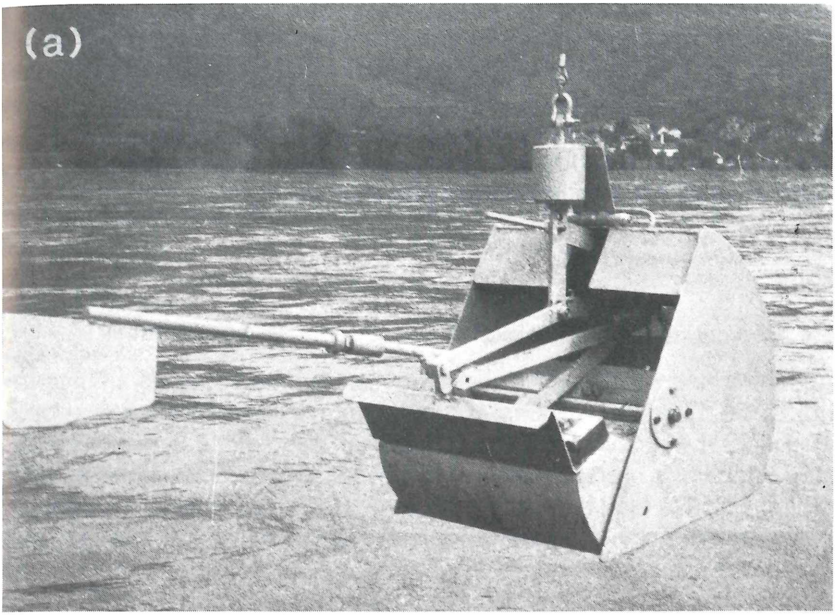
5.4.2 Quantitative sampling

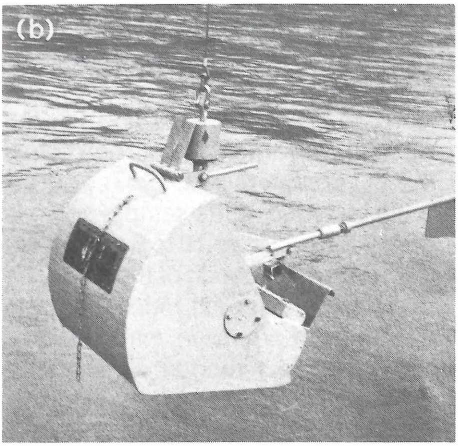
5.4.2.1 Petersen grab (modified by Niederreiter)

The Petersen grab (Petersen,1918; Fig. 5.4.4) weighs 45 kg (with two additional weights of 12.5 kg each) has a sampling area of 0.062 m^2 and two large jaws that swing shut automatically when sediment penetration releases the tension on the arming mechanism that holds the jaws apart. The arming mechanism consists of two pivoted arms (the scissors), which are locked into a V-groove by a pivoted cross bar, when the device, with its jaws in the open position is prepared for lowering. The cross bar is secured by a safty pin, which must be manually withdrawn when ready for lowering. To keep the grab in a straight position when lowered into the water, a tiller has to be placed at one end of the grab. As the jaws occasionally did not close properly because of jammed stones between them, there was a loss of surface sediment resulting in poor sample retention. Therefore a shovel has been added to the grab to cover the jaws when the grab is lifted. The closing mechanism of the jaws is linked to the shovel so that the latter moves around underneath the jaws during lifting of the grab. In the case of jammed stones between the jaws, the shovel protects the sediment from escaping. Pieces of solid shell of the shovel were replaced by metal screens (mesh aperture 500 μm) to decrease water resistance when lifting the grab from the bottom to the surface and to avoid a further wash-out of sediment [Plate 5.4.2(a)-(c)].

5.4.2.2 General performance

The bite profile of the grab has not been determined in the present study, but is described as a V-shaped profile (Birkett, 1958).
When reviewing the performance of the grab over the period of the whole investigation, two major influences on the sampling have to be considered. There is a permanent gradient of the particle size of the substratum across the river, ranging from a Q3 of 56 – 70 mm near the right bank to that of 16 – 19 mm near the left bank.Furthermore, temporary changes in the amount of discharge cause different water velocities ranging from 0.8 m sec^{-1} (for a Q of 677 m^3 sec^{-1}) to 2.1 m sec^{-1} (for a Q of 3115 m^3 sec^{-1}) (Table 5.4.1). Both influences are taken into account in the following discussion. The efficiency of the grab expressed as percentage of successful trials (one sample consisting of ten sampling units) from the total number of trials was remarkably similar at each site in spite of the differences in the composition of the bottom substratum (Table 5.4.1). Low efficiencies of about 47 % were observed only at high discharge rates of $\geq$3000 m^3 sec^{-1}.





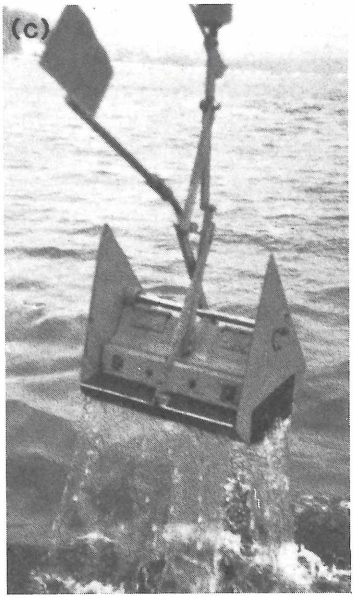


Plate 5.4.3. Petersen grab (modified by R. Niederreiter) – General arrangement: (a), (b) Before lowering. (c) After lifting.

The amount of substratum taken generally decreased as the particle size increased. The major exception was site 4 at a low discharge rate, with no obvious reason for this departure from the general pattern (Table 5.4.1). The mean depth of penetration was calculated indirectly by the volume of substratum in each catch. The mean values increased as substratum particle size decreased and low mean values of about 2.4 cm were observed at high discharge rates (Table 5.4.1).

5.4.2.3 Accuracy and precision

Accuracy refers to the difference between the mean density of invertebrates calculated from samples and the actual density on the river bed. Therefore the requirement for accurate sampling dictates that the measured density is representative of the population density within the substrate. Elliott & Drake (1981) performed tank experiments with plastic pellets to study the accuracy of different grabs and found that only two Ponar grab samplers were adequate for small stones (8 – 16 mm). No experiments of this kind have been undertaken in the present study.
Precision refers to the reproducibility of the result for the same population. Therefore the requirement of precise sampling dictates that the population estimates be repeatable. When ten replicate samples at four sites were taken, equal to forty sampling units, to characterize the number of macroinvertebrates per unit area at three sampling times, the 95 % confidence interval ranged from 357-804, 195-319 and 56-218 animals respectively per grab (Table 5.4.1). The index of precision D was calculated according to the formula $D = \sqrt{(s^2/n)}/\overline{x}$ (Elliott, 1977) where $\overline{x}$ is the arithmetic sample mean, s^2 is the variance of the sample and n is the number of sampling units. Values of D ranged from 10 to 26 %. When the number of macroinvertebrates per unit area for each of the four sites (equal to ten sampling units each) was analysed, a much wider lower and upper limit, and consequently a lower index of precision, was detected (Table 5.4.1). The number of sampling units (n) in a random sample for a certain index of precision D and for different percentages of probability level of D was calculated by $n = (t^2s^2)/(D^2\overline{x}^2)$ (Elliott, 1977), where t is found in the Student's t-distribution, s^2 is the variance of the sample and $\overline{x}$ is the arithmetic sample mean. The values of n are given in Table 5.4.1 and show for example that the number of sampling units for a precision of 20 % and a 70 % probability level vary from 3 to 67 according to different environmental conditions, e.g. different discharges.

Table 5.4.1. Summary of information on (a) hydrological variables and characteristics of the sediment analysis of the sampling area (total) and at different sites (30, 90, 200, 300 m from the right bank) for three typical discharge rates (low, medium and high); showing the water depth (in m), the water velocity (maximum and 10 cm above the bottom), the 25 %, 50 % and 75 % quantiles and the quantile deviation, the mean efficiency of the grab (in %), the mean depth of penetration (in cm) and the mean volume taken (in ml per grab). (b) Mean number of individuals per grab, the precision (in %) for ten sampling units in each sample and the number of sampling units needed for a given precision of 20 and 50 % of mean for a 70 % and 95 % probability level. C.L. = 95 % Confidence limits.

(1)
For $Q = 677\ m^3\ sec^{-1}$

Sampling sites (metres from the right bank)		30	90	200	300	Total
Site		1	2	3	4	
(a)						
Water depth in m		2.5	3.3	2.9	2.8	2.9
V_{max} m sec^{-1}		0.7	0.7	0.9	0.9	0.8
V_{10} cm sec^{-1}		0.4	0.3	0.5	0.5	0.4
Q1 (in mm)		31.3	25.6	12.0	8.9	15.2
Md (in mm)		46.3	37.2	16.7	16.4	21.6
Q3 (in mm)		61.1	54.7	20.2	20.1	41.3
QD		1.4	1.6	1.3	1.5	1.3
Mean efficiency (in %; with C.L.)		67 (42–86)	71 (55–92)	77 (61–100)	91 (54–100)	77 (63–917)
Mean depth of penetration (in cm; with C.L.)		3 (2–4)	3 (2–4)	2.6 (1.6–3.6)	4.6 (3.1–6.0)	3.7 (3.2–4.1)
Mean volume (in ml per grab; with C.L.)		2480 (1750–3210)	2490 (1690–3290)	2090 (1320–2860)	4200 (3390–5010)	2815 (2470-3160)
(b)						
Mean number per grab (with C.L.)		930 (578–1282)	933 (572–1294)	1905 (901–2910)	122 (56–159)	973 (357–804)
Precision (in %)		17	17	23	26	16
Number of sampling units for a precision % and C.L.%						
20	70	7	7	14	18	26
	95	36	38	70	90	108
50	70	1	1	2	3	4
	95	6	6	11	14	17

(2)
For $Q = 1836\ m^3\ sec^{-1}$

Sampling sites (metres from the right bank)	30	90	200	300	Total
Site	1	2	3	4	
(a)					
Water depth in m	3.5	3.0	3.5	3.0	3.3
$V_{max}\ m\ sec^{-1}$	1.3	1.6	1.7	1.5	1.5
$V_{10}\ cm\ sec^{-1}$	0.6	0.8	0.9	0.9	0.8
Q1 (in mm)	29.8	18.5	15.2	8.0	14.2
Md (in mm)	42.6	26.6	17.0	12.9	18.2
Q3 (in mm)	55.8	37.6	19.5	19.2	18.2
QD	1.4	1.4	1.1	1.5	1.2
Mean efficiency (in %; with C.L.)	91 (56–100)	71 (46–100)	67 (52–100)	91 (29–100)	80 (67–91)
Mean depth of penetration (in cm; with C.L.)	3.3 (2.8–3.8)	4.8 (3.8–5.9)	5 (3.4–6.6)	5.6 (3.9–7.3)	4.7 (4.2–5.2)
Mean volume (in ml per grab; with C.L.)	2390 (1920–2860)	4020 (2930–5110)	4230 (2910–5390)	5100 (3500–6700)	3935 (3450–4420)
(b)					
Mean number per grab with C.L.	447 (310–550)	485 (355–615)	169 (116–223)	175 (85–233)	319 (195–319)
Precision (in %)	14	12	14	24	10
Number of sampling units for a precision % and C.L.%					
20 70	5	3	5	14	11
95	27	18	25	73	46
50 70	1	1	1	2	2
95	4	3	4	12	7

(3)
For Q = 3115 $m^3 sec^{-1}$

Sampling sites (metres from the right bank)	30	90	200	300	Total
Site	1	2	3	4	
(a)					
Water depth in m	4.2	4.2	4.7	5.1	4.6
V_{max} m sec^{-1}	1.6	2.5	2.3	2.1	2.1
V_{10} cm sec^{-1}	0.7	0.6	1.1	0.8	0.8
Q1 (in mm)	26.3	36.3	15.3	9.7	15.6
Md (in mm)	33.8	50.6	17.4	15.9	17.6
Q3 (in mm)	70.1	63.3	21.3	19.0	37.8
QD	1.6	1.3	1.2	1.4	1.6
Mean efficiency (in %; with C.L.)	27 (20–35)	53 (36–96)	63 (45–96)	46 (31–59)	47 (33–59)
Mean depth of penetration (in cm; with C.L.)	1.9 (1.4–2.4)	2.0 (1.4–2.7)	2.4 (1.5–3.3)	3.3 (2.1–4.5)	2.4 (2.0–2.8)
Mean volume (in ml per grab; with C.L.)	1250 (920–1580)	1350 (860–1840)	1670 (950–2380)	2570 (1540–3600)	1710 (1400–2020)
(b)					
Mean number per grab with C.L.	1787 (985–2358)	386 (246–526)	18 (8–23)	31 (9–39)	555 (193–1592)
Precision (in %)	19	16	32	42	26
Number of sampling units for a precision % and C.L.%					
20 — 70	9	6	26	44	67
95	47	33	13	225	278
50 — 70	1	1	4	7	11
95	8	5	22	36	44

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