

Fecundity and Gonadosomatic Index of Sucker Throat Catfish, *Pseudecheneis sulcata* (McClelland, 1842) from the Snow-fed Tamor River in Eastern Nepal

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ABSTRACT

In comparison to other nations, the Nepalese information on the reproductive biology of hill-stream fish is limited. So, the purpose of the present study was to provide information related to reproductive biology of a hill-stream sucker throat catfish *Pseudecheneis sulcata* from the snow-fed Tamor River, Nepal. The study was carried out from June 2018 to May 2019. A total of 57 female fish was collected. The fecundity of 22 females was assessed, while the gonadosomatic index was determined using all the collected samples. The absolute fecundity ranged from 2,316 to 7,597 eggs, with an average of $3,660 \pm 210$. This range of absolute fecundity indicates that *Pseudecheneis sulcata* is a moderately fecund fish when compared to certain low fecund species and some exceptionally fecund fish with tens of thousands of eggs. Relative fecundity ranged from 65.47 to 129.11 with a mean of 88.98 ± 4.35 . The present study demonstrated that absolute fecundity was moderately correlated with total length ($r = 0.45$) and strongly linked with body weight ($r = 0.78$), and ovary weight ($r = 0.80$). Mean gonadosomatic index (GSI) was recorded the highest in January ($15.7 \pm 1.22\%$), and showed a decrease in the subsequent month of February ($10.3 \pm 0.75\%$), March ($6.25 \pm 0.28\%$) and April ($1.66 \pm 0.40\%$). The trends of GSI might have indicated that the sucker throat catfish was a batch spawner, with spawning season occurring between January and March.

Keywords: Catfish, glacier fed, hill stream, reproductive biology

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INTRODUCTION

Pseudecheneis sulcata is a unique fish, commonly known as sucker throat catfish. It inhabits fast flowing hill-streams, with the bottom of sand, gravel, rocks and is native to fresh water bodies of Southern Asia, i.e. Bangladesh and India (Ng, 2010). It also inhabits the fresh water bodies like Gandaki, Seti and Koshi Rivers of Nepal (Shrestha, 2019). Sucker-like mouth encircled by many fimbriated barbs and a ventrally situated adhesive pad with 10-12 transverse ridges are among the adaptive modifications. The fish is a bottom dweller which mainly feeds upon other bottom dweller crustaceans, algae attached to rocks, some aquatic insects, larvae etc. Fecundity is the ability to produce an abundance of offsprings. Fecundity, gonadosomatic index (GSI), and lengths at sexual maturity are crucial biological characteristics for understanding the

reproductive dynamics of certain fish species, as these characteristics reveal their maturity and spawning activity (Murua *et al.*, 2003; Rasheed & Mustaqim, 2010). In context of fish biology, it is defined as the number of mature ova present in the ovary of gravid female fish and relative fecundity is the number of ova per gram of fish weight. Instead of measuring reproductive fertility, fecundity is studied as a point of reproductive measurement (Moyle & Cech, 2000).

Fecundity is defined as an individual's physiological maximum potential reproductive production across their lifetime, and it is a crucial cornerstone of both theoretical and applied population biology (Bradshaw & McMahon, 2008). Moreover, Flores *et al.* (2015) stated that gonadosomatic index is a metric that represents the relative weight of the gonad to the fish weight. The peak period of maturity and the spawning

season can be detected by the study of GSI of fish.

Human activities, fishing pressure, climate change, ongoing road building, micro-hydropower generation, the use of herbicides, electro-fishing, deforestation, and water diversion have all contributed to the decline of several Nepalese fisheries populations (Adhikari *et al.*, 2021; Limbu *et al.*, 2021a). Moreover, mostly in the hill side of Nepal, ongoing road development is found to be major threat to the present fish species such as *Pseudecheneis* spp., *Garra* spp., *Schizothorax* spp., *Shistura* spp. and *Nemachelius* spp. (Limbu *et al.*, 2021b; Prasad *et al.*, 2020).

There is no such sufficient information about the biology and population dynamic of *P. sulcata*, though it is believed that the fish is abundantly found in the fresh water of Southern Asia and regarded as least concern in the Red list of IUCN (Ng, 2010). The published literature on the reproductive aspect on this species is very scanty. Thus, the present study of fecundity attempted to enhance the knowledge of the reproductive biology of *P. sulcata* as well as provide the necessary information for its conservational strategy.

MATERIALS AND METHODS

Study Area

Tamor River lies in the eastern Nepal, which begins around Kanchenjunga (Figure 1). It is one of the seven major tributaries of Giant Saptakoshi River of Nepal. It lies between the latitude and longitude coordinates of N 26°54'47" and E 87°09'30", respectively. The river and its main tributaries originate from Mount Kanchenjunga

which is the third highest peak in the world and flows towards eastern part of country. The Tamor and Arun join the Sunkoshi at Tribenighat to form the Giant Saptakoshi River which flows through Mahabharat range. The total length of the river is approximately 190 km with catchment area of 5817 km² (Shrestha *et al.*, 2009). Boulders, cobbles, pebbles, gravels and sand were the major characteristic feature of the bottom of this river.

Data Collection

Sample collection

Sampling was conducted once a month for a year at four different sampling sites. The female fish were collected from their natural habitat from June 2018 to May 2019 by using two cast nets of different sizes, with one having large mesh size with 2 cm, 6 m diameter and 6 kg weight and another having 0.5 cm, 3 m diameter and 2 kg weight. However, sampling was restricted in some areas due to difficulties of access. In addition, monofilament gill nets with mesh sizes of 6, 8, and 10 mm were used to capture the fish. In each station, nine gill nets were left late in the evening (5 p.m. - 6 p.m.) and taken out early in the morning (6 a.m. - 7 a.m.) in a sampling distance of 150 - 200 m (Limbu *et al.*, 2021a). Samples were preserved in 8-10% formaldehyde solution and brought to the laboratory of Post Graduate Campus, Biratnagar for further investigation.

Measurement of length and weight

A total of 57 specimens of female *P. sulcata* was sampled during the study period. Each specimen's total length (TL) and body weight (BW) were

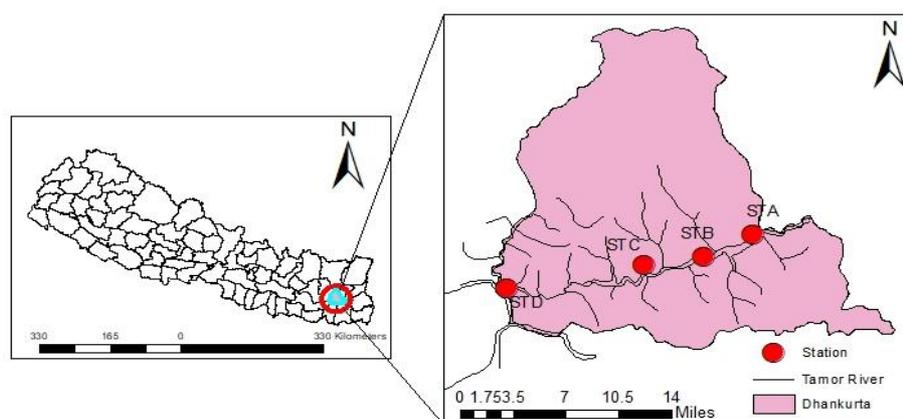


Figure 1. Map of study area showing Tamor River

measured to the nearest the nearest 0.01 cm and 0.01 g using a measuring scale and a digital electronic weighing balance, respectively. Fish were dissected to expose ovaries. The ovary of each fish was carefully taken out and weighed in weighing balance after soaking water with blotting paper.

Gonadosomatic index (GSI)

The gonadosomatic index of each specimen was calculated and recorded with respect to the months. Mathematically, GSI of each fish was calculated by using the following formula.

$$GSI = \frac{\text{ovary weight}}{\text{total weight of fish}} \times 100 \quad (1)$$

Fecundity estimation

A total of 22 mature female fish was used for fecundity estimation. Fecundity was estimated using a gravimetric method (Hunter & Goldberg, 1980; Hunter *et al.*, 1992; Murua *et al.*, 2003). The ovary of the catfish is bi-lobed. Ovary was cut off into three parts (samples) i.e. anterior, middle and posterior. Then from each sample, 50 mg of sub-samples were taken and kept in Gilson's fluid for 5 - 7 days. The Gilson's fluid was prepared in the laboratory. The Gilson's fluid loosens the connective tissues and makes easy for separating the eggs. The separated eggs were counted using the hand lens (5X) and pointed needle. The total number of eggs in each ovary samples were estimated using the equation as follows.

$$f_1 = \frac{\text{Ovary weight} \times \text{Number of oocytes in the subsample}}{\text{weight of subsample taken}} \quad (2)$$

Subsequently, the total absolute fecundity (F) for each female fish was estimated by taking the mean of all three sample fecundities i.e. f_1 , f_2 , f_3 . Furthermore, relative fecundity was estimated by dividing individual absolute fecundity with the weight of respective fish.

Data Analysis

The analysis of variance (ANOVA) was used to assess significant variations in the GSI index across samples taken on different months. A post hoc Tukey HSD test was employed to identify which means were significantly different at a 0.05

significance level (Spjøtvoll & Sttoline, 1973). Pearson's correlation coefficient (r) and regression equations were used to determine the strength and significance of the connections between absolute fecundity, total length and weight, and gonad weight. All the data were analyzed in R (R core team, 2019) and Microsoft Excel 2010 software.

RESULTS

The absolute fecundity ranged from 2,316 to 7,597 eggs in fish of TL range of 13.6 cm to 18.3 cm, body weight range of 21.81 g to 68.25 g and ovary weight range of 1.17 g to 11.87 g (Table 1). The highest fecundity was found to be 7597 eggs in the fish measuring 18.3 cm TL, 68.25 g BW and 11.87 g OW while the fecundity was counted 2316 in the specimen measuring 15.7 cm TL, 23.89 g TW and 1.17 g OW. Mean fecundity of fish was found to be 3660 ± 210 at the mean length of 16.14 ± 0.31 cm, 43.29 ± 2.87 g in mean total weight and 5.24 ± 0.63 g mean ovary weight of fish (Table 1).

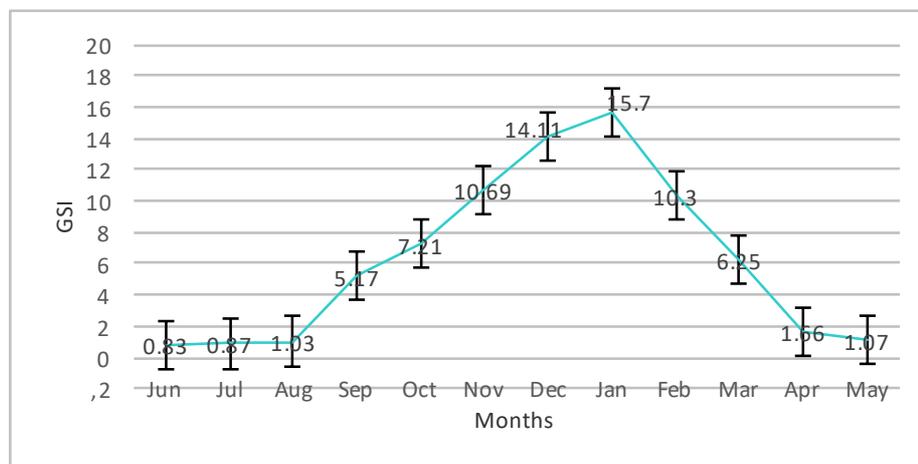
The relative fecundity to weight ranged from 65.47 in the fish measuring total weight 59.64 to 129.11 g in the fish measuring total weight 21.81 g. Mean relative fecundity was found to be 88.98 ± 4.35 . The highest value of mean GSI was seen during the month of January ($15.70 \pm 1.22\%$), which decreased to $10.30 \pm 0.75\%$ in the month of February and also showed continuous decreasing trend during the month of March and April to $6.25 \pm 0.28\%$ and $1.66 \pm 0.40\%$, respectively. This ongoing decrease in the GSI suggested that fraction of eggs were spawned during several months. The variation of monthly GSI values for female fish showed that fish spawned during the month of late January to late March (Figure 2, Table 2). An analysis of variance (ANOVA) pointed that there is a significant ($p < 0.001$) difference between the GSI in 12 months but Tukey HSD test indicated that there was no significant ($p = 0.09$) difference between the months of November and December.

Fecundity of fish varied from 2,316 to 7,597 in the fish measuring 15.7 to 18.3 cm in TL (Table 1). Straight line was obtained while plotting the values of fecundity and TL with the coordinates Y-axis and X-axis respectively (Figure 3). Regression equation was obtained as follows.

$$y = 302.11x - 1216.9 \quad (3)$$

Table 1. Total length, body weight, ovary weight and absolute fecundity of sampled female *Pseudecheneis sulcatus* from Tamor River, Nepal

S.N	Body Weight W (g)	Total length TL (cm)	Ovary Weight OW (g)	Absolute fecundity (F)	Relative fecundity to total weight (RF)
1	55.43	16.7	7.9	3914	70.61
2	68.25	18.3	11.87	7597	111.31
3	47.68	16.4	5.22	3515	73.72
4	33.46	14.1	6.26	3654	109.20
5	50.75	14.8	10.24	4018	79.17
6	52.89	17.5	6.96	3715	70.24
7	45.75	17.1	7.01	3872	84.63
8	59.64	18.1	5.02	3905	65.47
9	50.39	17.7	5.18	3496	69.37
10	52.17	15.3	4.96	3621	69.40
11	48.89	15.1	6.36	3674	75.14
12	50.67	16.9	5.25	3487	68.81
13	28.17	15	1.75	3115	110.57
14	21.81	13.6	1.60	2816	129.11
15	23.89	15.7	1.17	2316	96.94
16	30.1	15.2	1.79	3174	105.44
17	25.37	14.7	1.59	2798	110.28
18	25.88	17.5	1.7	3015	116.49
19	27.65	14.2	1.83	3197	115.62
20	53.17	18.1	7.59	3951	74.30
21	48.61	17.8	6.8	3682	75.74
22	51.8	15.4	7.3	3942	76.10
Mean ± SE	43.29 ± 2.87	16.14 ± 0.31	5.24 ± 0.63	3660.77 ± 210.74	88.98 ± 4.35

**Figure 2.** Mean monthly gonadosomatic index of *Pseudecheneis sulcatus*

The correlation coefficient was $r = 0.452$ ($p = 0.0067$), which implied significantly positively relationship between the ovary weight and fecundity.

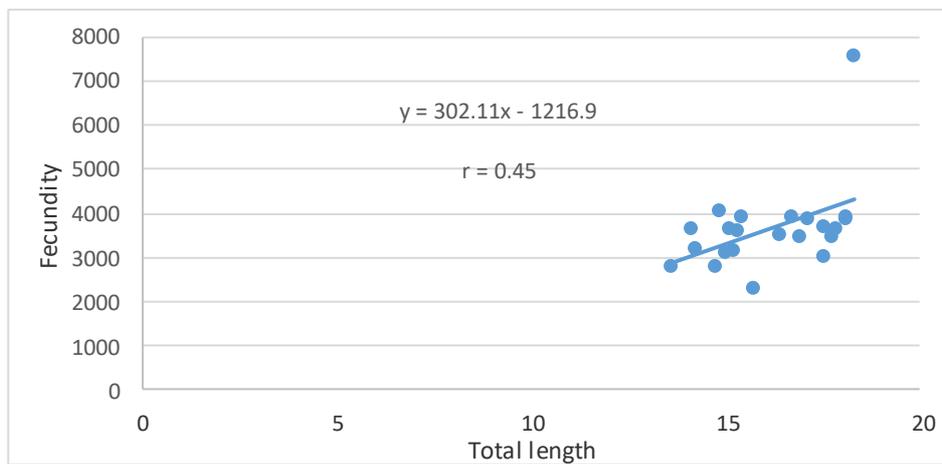
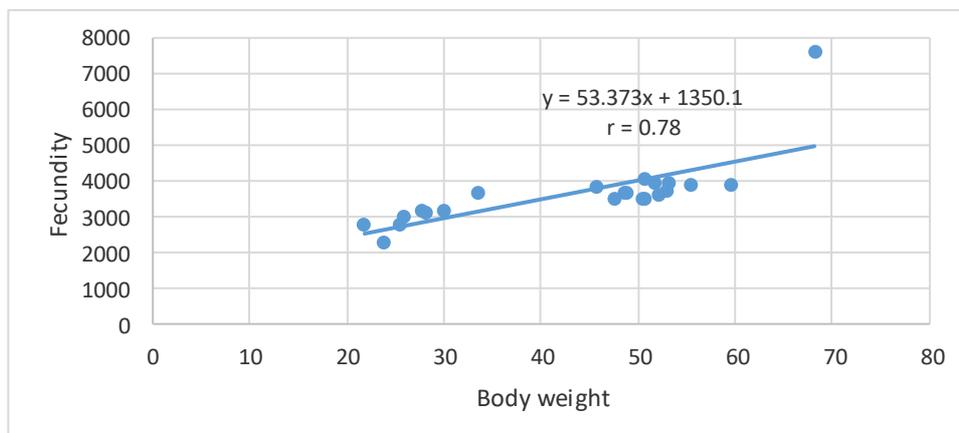
Fecundity of fish varied from 2,316 to 7,597 in the fish measuring 21.81 g to 68.25 g in BW. Straight line was obtained while plotting the

values of fecundity and total weight with the coordinates Y-axis and X-axis respectively (Figure 4). Regression equation was obtained as follows.

$$y = 53.373x + 1350.1 \quad (4)$$

Table 2. Monthly gonadosomatic index of *Pseudecheneis sulcata*

Months	No. of fish examined	GSI range	Mean GSI
June 2018	2	0.61-1.05	0.83
July 2018	4	0.63-1.05	0.87
August 2018	6	0.85-1.27	1.03
September 2018	5	4.79-6.08	5.17
October 2018	9	5.83-9.17	7.21
November 2018	4	9.85-11.37	10.69
December 2018	3	13.98-14.27	14.11
January 2019	7	10.94-20.17	15.7
February 2019	5	8.41-10.36	10.3
March 2019	7	4.89-7.33	6.25
April 2019	3	0.85-2.11	1.66
May 2019	2	1.05-1.09	1.07

**Figure 3.** Relationship of fecundity with total length of *Pseudecheneis sulcata***Figure 4.** Relationship of fecundity with body weight of *Pseudecheneis sulcata*

The correlation coefficient (r) of 0.78 was obtained ($p = 0.005$), which implied that there was positive correlation.

Fecundity of fish varied from 2,316 to 7,597 in the fish measuring 1.17 g to 11.87 g in ovary weight. Straight line was obtained while plotting the values of fecundity and ovary weight with the coordinates Y-axis and X-axis respectively

(Figure 5). Regression equation was obtained as follows.

$$y = 264.49x + 2274 \quad (5)$$

The correlation coefficient (r) of 0.8 was obtained, which implied that there was positive correlation and was highly significant ($p = 0.0057$).

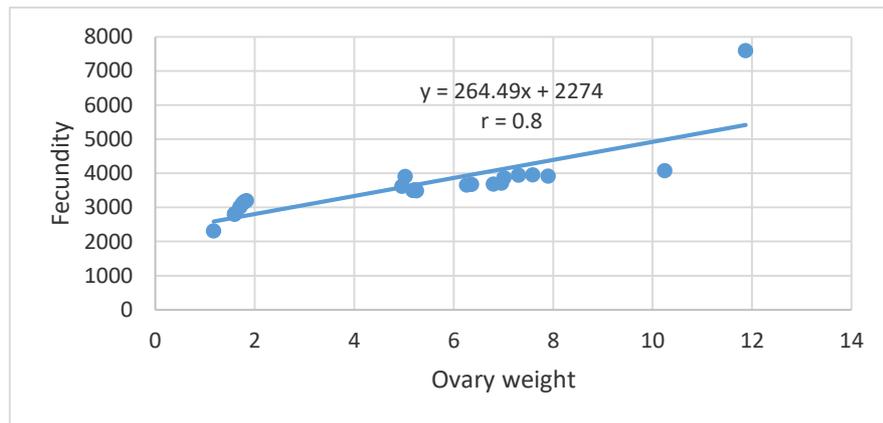


Figure 5. Relationship between fecundity and ovary weight of *Pseudecheneis sulcata*

DISCUSSION

Throughout the study period, total weight of the 22 female fish *P. sulcata* specimens ranged from 21.81 to 68.25 g. It differed from each other on the different sampling months (Table 1). The fish accomplished the highest length in January and the lowest length in May. In the present study, the ovarian weight ranged from 1.17 to 11.87 g. Generally, the ovarian weight of the fish depends on the number of oocytes and the degree of maturity of female fish (Hasan *et al.*, 2020). The gravimetric method done in this study was also applied by many researchers (Blay, 1981; Mustafa *et al.*, 1983; Nandikeswari *et al.*, 2014; Hasan *et al.*, 2020). The present study showed the fecundity of fish ranged from 2316 to 7597. The highest fecundity was found to be 7597 in the fish measuring 18.3 cm TL, 68.25 g TW and 11.87 g OW whereas, lowest fecundity was recorded as 2316 in the specimen measuring 15.7 cm TL, 23.89 g TW and 1.17 g OW. This range of fecundity made *P. sulcata* a moderately fecund fish compared to some of highly fecund fishes with tens of thousands of eggs and some low fecund fishes with hundreds of eggs.

Thapliyal and Balodi (2015) studied the fecundity of *P. sulcata* in Alaknanda, Garhwal

Himalaya and reported the range of fecundity similar to present study but spawning season was found to be occurring during the month of June-July whereas, in the present study *P. sulcata* showed the spawning season coinciding with the month of late January to late March. The difference in the spawning season of same species might be due to the ecological condition of streams and different in monsoon arrival time which caused the maturation of fish. The ecological condition of streams and early arrival of monsoon plays important role on maturation phases and might cause slight difference in spawning season.

The present study reported highest mean (GSI) of fish in the month of January ($15.70 \pm 1.22\%$), which ongoing fell to $10.30 \pm 0.75\%$, $6.25 \pm 0.28\%$ and $1.66 \pm 0.40\%$ in the month of February, March and April respectively. This implied the spawning season of fish coincides with the month of January to March.

The regression equations and scattered diagrams showed a positive but non-robust relationship of fecundity with the total length ($r = 0.8$) and total weight ($r = 0.78$) but poorly correlated with total length ($r = 0.452$).

In contrary, a similar strong association between fecundity and body weight was discovered. As a result, it is clear that as the standard length and or body weight of *P. sulcata* grew, the fecundity or number of oocytes increased as well. This is due to the fact that larger fish have more accessible energy and a larger body cavity for the development of oocytes (Jonsson & Jonsson, 1999). Furthermore, the findings of Kabir *et al.* (1998) is analogous to the current findings. The ability of fish to produce oocytes is influenced by a variety of physical and environmental parameters, including age, sex, size, species type (Hunter *et al.*, 1992), life history, and water temperature (Mousavi-Sabet *et al.*, 2017).

The human-induced activities like electrofishing, poisoning of river, mass fishing, detonation in the name of economics and fun had become serious threat to the population of *P. sulcata* and whole fish diversity of Tamor River. Moreover, ongoing road development, micro-hydropower generation, the use of poisonous herbicides, illegal electro-fishing, deforestation and water diversion are all found to be major threats to the present fish species of Nepal's rivers, stream, ponds, lakes and reservoir (Limbu *et al.*, 2020; 2021). Therefore, for the better monitor, management and conservation of Nepal's indigenous fish species, habitat rehabilitation, and construction of fish ladders/passage are necessarily needed. Moreover, extraction and transportation of boulders, cobbles, pebbles and sand mining are also stringently stopped in ordered to avoid the habitat destruction of aquatic fauna and flora including fish.

CONCLUSION

The fertility of 22 females was evaluated, and the gonadosomatic index was calculated using all of the samples gathered. The absolute fecundity ranged from 2316 to 7597 eggs with an average of 3660 ± 210 . When compared to some low-fecund species and some very fecund fish with tens of thousands of eggs, this range of absolute fecundity indicates that *Pseudecheneis sulcata* is a fairly fecund fish. Relative fecundity ranged from 65.47 to 129.11 with a mean of 88.98 ± 4.35 . The highest mean gonadosomatic index (GSI) was reported in January (15.7 ± 1.22 %), followed by decreases in February (10.3 ± 0.75 %), March (6.25 ± 0.28 %) and April (1.66 ± 0.40 %). The sucker throat catfish's GSI pattern may have

indicated that it was a batch spawner, with spawning season falling between January and March. This period of months might need to be incorporated in managing fisheries resources in the Tamor River.

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