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## Records of *Chymomyza* (Drosophilidae, Diptera) species in Switzerland

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Among adult *Chymomyza* flies collected from forest trees, four native species known to occur in Switzerland were present at many sites. As a rule, males outnumbered females. Two or more species coexisted on leks. There is evidence of aggregation within species and of dissociation between them. Under similar conditions, six *Drosophila* species and one *Scaptomyza* species were found.

Keywords: phenology, sex ratio, aggregation, lek, coexistence, Drosophilidae.

### INTRODUCTION

As far as known, in Switzerland the drosophilid genus *Chymomyza* is represented by five species (BÄCHLI & BURLA, 1985; MACA & BÄCHLI, 1994). Four of them are collected in forests almost exclusively, and thus may be considered native. Two of them, namely *C. fuscimana* and *C. distincta*, are light brown, the other two, *C. costata* and *C. caudatula*, blackish. The fifth species, *C. amoena*, is a fairly recent immigrant, or import, from the USA (BAND, 1995b; BURLA & BÄCHLI, 1992; MACA & BÄCHLI, 1994). Because no more than two specimens were recorded in the present study, this species will only be discussed at the end.

Beginning on July 1, 1993, the native species were collected in two parts of Switzerland: in a Midland forest near Zurich and an alpine forest near the locality Tinizong in the Oberhalbstein Valley. The present report deals with the numbers of collected males and females and the proportions of species, separate by region, site, tree species, season and daytime. There is evidence for coexistence, and instances of both dissociation and aggregation.

### MATERIAL AND METHODS

#### *Collecting sites*

From July 1 to September 18, 1993, and again from April 23 to September 26, 1994, *Chymomyza* flies were collected at 17 Midland and 2 alpine sites, in forests where cut trees and smaller logs were stacked for a shorter or longer time, and tree stumps persisted. Three more alpine collecting sites were lumberyards in the Oberhalbstein. The Midland sites were in forests around Gockhausen, which is a small village on the slope of a hill east of Zurich. There, most of the deciduous trees are beech (*Fagus sylvatica*), fewer are maple (*Acer platanoides*), ash (*Fraxinus excelsior*) and oak (*Quercus robur*). Most of the coniferous trees are spruce (*Picea abies*), fewer are fir (*Abies alba*), pine (*Pinus sylvestris*) and larch (*Larix decidua*). Most wood is cut during winter and involves spruce predominantly. The alpine sites are

near the village of Tinizong in the Oberhalbstein Valley of eastern Switzerland. Two of the alpine lumberyards were in forests, the third on the cleared valley bottom along the bank of the river Julia. In each a large number of logs were stacked after being cut weeks or months before. Incoming logs are sprayed with pesticide after being peeled. On both sides of the valley, large parts of the high slopes are covered with forest between 1200 m and 2000 m of altitude. Most trees are spruce (*Picea abies*). Wood is cut from spring to fall. At one site of the western valley slope, an area of about 2500 m<sup>2</sup> was selected at 1300 m altitude, in a forest continuous over about 7 km<sup>2</sup>. In the area spruce trees were cut in summer 1992, and a few more in spring 1993. When clearing the area from the logs, the stumps as well as worthless logs were left. The area was searched for *Chymomyza* in August 1993 and again in June and July 1994. In spring 1994 several hundred trees were cut in an area 150 m higher up on the same slope. This area was searched for *Chymomyza* in June and July 1994. On each of these occasions the lumberyards were visited as well.

In Switzerland, 20 collections were made in 1993 and 44 in 1994. In the first year, two more collections were made in a forest at Klippeneck in the German Schwäbische Alb.

### *Collecting methods*

The proportion of *Chymomyza* is usually very low among flies which are netted over bait. It was 0.01 % among 258'000 drosophilid flies collected over banana bait in Switzerland (Dr. G. BÄCHLI, pers. comm.). The proportion was higher in Finland where 2'000 *C. costata* flies were trapped over malt bait, along with 19'000 other drosophilids, while the 3 other native *Chymomyza* species were almost as rarely found as during the present study in Switzerland (HACKMAN *et al.*, 1970). A more direct way to collect *Chymomyza* flies is to look for them on cut and damaged trees and capture them one by one by means of an aspirator or a glass vial. It not only increases the yield but also provides information on natural habitat and diurnal activity, by species and sex. The vial is advantageous for catching the flies on the smooth ends of cut trees. The aspirator, ending in a narrow glass tube, is used for catching flies from deeply sculptured bark. Because flies are often alerted by the approaching collector and then may escape, it is advisable to keep the distance large. For this purpose the aspirator ends in a long glass tube. For the same reason the vial was stuck into the end of a tube, 30 cm long, made of colorless transparent polyethylene, serving as a handle.

The four native species coexist in deciduous as well as coniferous forests, from low to high altitude. They are most easily seen on freshly exposed wood such as spots where the bark is removed, or on cut ends. Most of the present records are from such sites. However, the flies also move on the undamaged bark of trees where they are less easily detected. Usually the *Chymomyza* flies show up singly or in low numbers, and thus are considered to be rare. They may be numerous on damaged or freshly cut trees. Exceptionally they show up in very large numbers. *Chymomyza* flies announce their presence by moving jerkily and waving wings. On this occasion they are easy to catch, as they seem to ignore the danger of being trapped. Fewer flies stay immobile; these rather seem ready to escape fast. Females remain immobile more often than males.

The best yield is obtained in a forest area where only one, or very few, trees are freshly damaged or cut. In an area where many trees are cut, the flies become thinly dispersed which may reduce the yield. The same situation occurs in large

lumberyards where more logs are attractive to flies than can be carefully examined. *Chymomyza* flies may be seen on a freshly injured or cut tree a few hours after the injury occurred. In the following days the number of flies at this place increases, but will decrease after about a month. Trees cut a year, or years, ago, do not usually seem to attract *Chymomyza* flies any longer.

### Statistics

Tab. 1, 2 and 5 represent parts of a multidimensional contingency table which contains all the original data, spread over a large number of cells. At computing, the information might be partitioned according to all effects to be considered: fly species, years, seasons, daytimes, sites, habitats, tree species, time elapsed after cutting a sampled tree, and weather conditions. Yet, in many cells of the table the frequency would be very small, often zero. Most effects would not be significant. Also, collecting was not done systematically enough to warrant equal treatment of all effects. Under this condition no contingency test was carried out for the comprehensive table. In Tab. 3 to 5 the observed numbers of flies are compared with expected numbers, computed from marginal totals and rounded to the nearest integer. A contingency table chi-square along with the corresponding degrees of freedom and the p value are mentioned in the captions. This practise involves overinterpretation of the data. It is left to the reader to wisely interpret the biological relevance in each case.

## RESULTS

### *Fly numbers and species proportions*

The records from all 64 collections are summarized in Tab. 1. At Gockhausen the rank order of abundance was *C. fuscimana* > *C. caudatula* > *C. distincta* > *C. costata* in both years. At the alpine sites including the lumberyards, *C. caudatula* was lacking, and *C. costata* was more frequent than *C. distincta*. An increase of the *C. costata* frequency along with altitude would be in line with a well documented latitudinal cline in Finland (HACKMAN *et al.*, 1970). However, the present effect was due to a single event: 19 *C. costata* flies from Tinizong were from two spruce stumps 2 m apart, out of a vast forest where many logs and stumps had been examined for flies.

In a forest near Klippeneck of the German Schwäbische Alb a stack of spruce logs was searched for *Chymomyza* on the evening of August 12, 1993 and the following morning. One female, 3 males of *C. costata* and 1 female, 7 males of *C. fuscimana* were found.

### *Sex ratio*

In Tab. 1 a predominance of males over females is striking in all species. Since in laboratory stocks the sexes emerge in approximately equal numbers, the collecting data may be explained by assuming that males and females differ by utilization of habitat compartments, or by diurnal activity. Females seem to expose themselves to sight more cautiously than males. They leave an exposed place as soon as mating is accomplished.

Tab. 1 – Total numbers of *Chymomyza* flies collected in Midland forests (Gockhausen, near Zurich) and alpine forests (Tinizong, Oberhalbstein) as well as in 3 alpine lumberyards.

		<i>C. caudatula</i>		<i>C. costata</i>		<i>C. distincta</i>		<i>C. fuscimana</i>		row sum
		♀	♂	♀	♂	♀	♂	♀	♂	
Gockhausen forests	1993	0	19	1	1	0	13	13	54	101
	1994	14	48	3	6	14	35	58	178	356
	column sum	14	67	4	7	14	48	71	232	457
	total by species		81		11		62		303	457
Tinizong forests	1993	0	0	2	2	0	0	8	25	37
	1994	0	0	6	13	0	0	4	12	35
	column sum	0	0	8	15	0	2	12	37	74
	total by species		0		23		2		49	74
lumberyards	1993	0	0	4	2	1	3	0	6	16
	1994	0	0	2	9	2	5	8	34	60
	column sum	0	0	6	11	3	8	8	40	76
	total by species		0		17		11		48	76
all sites	column sum	14	67	18	33	17	58	91	309	607
	total by species		81		51		75		400	607

Tab. 2 – Collecting records from Gockhausen forests in 1994, separate by eleven time intervals of half a month, for phenological assessment. A\_2, second half of April, M\_1, first half of May, and so on. Sexes pooled.

interval nr part of month	1 A_2	2 M_1	3 M_2	4 Jn_1	5 Jn_2	6 Jl_1	7 Jl_2	8 A_1	9 A_2	10 S_1	11 S_2	sum
<i>C. caudatula</i>	3	3				12	17	26	20			81
<i>C. costata</i>							31	14	6			51
<i>C. distincta</i>						2	25	13	20	15		75
<i>C. fuscimana</i>			24	14		5	94	101	75	32	55	400
sum	3	3	24	14	0	19	167	154	121	47	55	607

### Phenology

The records taken in 1994 in Gockhausen forests may be of phenological interest. In Tab. 2 they are printed over a time period from mid-April to end of September, in eleven intervals, each half a month long. This period does not encompass the entire period of presence of the flies. In other years, flies were seen to occur earlier and later.

After *C. caudatula* was collected in spring as the earliest species, it disappeared from the records, to show up again two months later. This pattern suggests a bimodal periodicity of abundance. *C. fuscimana* was the latest species recorded in fall. The abundance of all four species increases from spring to fall.

Yet, the data must be considered with caution. A rare species, such as *C. caudatula*, may easily show as absent when in reality it is present. Collecting, though

frequent, was irregular. It ought to be done according to a regular scheme, in more than two years.

### *Habitats*

Where in lumberyards logs of various diameter are stacked, more flies were found on large cut ends than on small ones.

Between August 13 and 28, 1994, *Chymomyza* flies were collected eight times on a windfallen beech. The log was 27 m long and its diameter at the lower cut end was 1 m. The flies were separately counted at three parts of the log: on the cut end; on the bark of the trunk; on various damaged parts of the trunk where the bark was removed. In Tab. 3 the numbers in the cells represent the total numbers of flies from the eight collections. Comparing observed with expected numbers, the four species seem to be homogeneously dispersed. However, the visible part of the surface of the trunk was about 30 times larger than the surface of the lower cut end. The fact that 35 percent of the flies were collected on the cut end suggests that this part was more attractive than the others.

Some twenty meters apart there was a spruce tree with several patches of bark removed by the impact of the falling beech. Three patches were in reach. In Tab. 4 the number of flies from the spruce is compared with the number from the beech. While the proportion on both trees was about the same in *C. fuscimana*, it differed between trees in the other species. It suggests that *Chymomyza* species respond differently to spruce and beech.

When in an alpine lumberyard a piece of loose bark was pulled from a spruce log, a *Chymomyza* fly was seen rather far from the edge, resting among mould. The fly escaped before it could be collected.

### *Way of moving*

The flies move in short spurts and wave wings when they halt. This may help them to encounter conspecific flies. Otherwise, the species differ in the way of moving. *C. costata* moves more slowly and less steadily than the two yellow species. Also it waves wings less often and less dramatically. *C. caudatula* resembles *C. costata* with regard to wingwaving, but may move more steadily and as fast as the two yellow species. *C. caudatula* looks depressed while the yellow species look long-legged. Of the latter, *C. fuscimana* is a little larger, on the average, and seems to move more imposingly. Often a cautiously moving yellow fly turned out to be *C. distincta*. Thus it seems possible to tell the species apart by eye in nature, some errors granted. Both black species are easier to collect by surprise than the yellow ones.

The flies moved on the smooth bark of the beech logs in the same conspicuous way as on the patches of removed bark and the cut ends. When two flies met, they interacted in the typical manner. Often the flies changed without hesitation from wood to bark, or vice versa. However they seemed to recognize the bark when approaching it. If in danger (to be captured) they often hid at the edge of the bark. Those which were on a cut end often turned around the edge to the bark on similar situations.

Wing waving, usually while moving, is more vigorous and more often seen in males than in females. Often a female stayed motionless in the center of a cut end in the absence of males. The place could be a deserted, or not yet occupied, lek.



Tab. 3 – Flies collected from a windfallen beech of which the split lower end was cut. Fly numbers are given separate by 3 parts of the log: cut lower end; bark, as far as accessible for inspection; damaged parts of the trunk where the bark was removed. Estimated surfaces in m<sup>2</sup>. Contingency table chi-square = 10.64, d.f. = 6, p = 0.1002.

beech log	surface	<i>Chymomyza</i> <i>caudatula</i> <i>costata</i> <i>distincta</i> <i>fuscimana</i>				row sum
		<b>observed numbers</b>				
lower cut end	0.2	2	3	2	17	24
bark	12.6	13	0	2	33	48
spots of exposed wood	1.4	9	1	1	17	28
	sum	24	4	5	67	100
		<b>expected numbers</b>				
lower cut end		6	1	1	16	24
bark		12	2	2	32	48
spots of exposed wood		7	1	1	19	28
	sum	25	4	4	67	100

Tab. 4 – Numbers of flies collected from a windfallen beech (*Fagus sylvatica*) and a damaged spruce (*Picea abies*) 20 m apart. The records from beech refer to the same tree as mentioned in Tab. 3, but include additional flies which were collected earlier and later. Thus the numbers in the two tables are not entirely comparable. Contingency table chi-square = 19.50, d.f. = 3, p = 0.0002.

	<i>Chymomyza</i> <i>caudatula</i> <i>costata</i> <i>distincta</i> <i>fuscimana</i>	row sum
	<b>observed numbers</b>	
from a spruce	4   4   12   30	50
from a fallen beech	32   4   6   77	119
sum	36   8   18   107	169
	<b>expected numbers</b>	
from a spruce	11   2   5   32	50
from a fallen beech	25   6   13   75	119
sum	36   8   18   107	169

### Leks

A lek is a site where species members aggregate for mating. Primarily males dominate by frequency and are often involved in rival contests. Females which are ready to mate may join them one by one. The aggregated dispersion pattern among *Chymomyza* flies which are ready to mate points to leks. Actually, leks were observed in *Chymomyza* before (BAND, 1988b). A similar situation, though different in many details, holds in the Hawaiian picture-winged *Drosophila* (SPIETH, 1984) and the Nearctic species of the drosophilid genus *Zygothrica* (BURLA, 1990), just to mention two exotic taxa which are prominent in this respect.

However, *Chymomyza* flies move in spurts and wave wings also at other sites, for instance on the bark of logs. If there are conspicuous leks in *Chymomyza*, courting behavior is not restricted to them.

### *Diurnal activity*

All four *Chymomyza* species could be collected from dawn to dusk. They may be less numerous at noon if they are exposed to bright sunlight and low humidity of the air. In the evening they are active until they become invisible in the dark. If the flies are sorted according to the daytime in which they were collected, the frequency of each species varies during the day (Tab. 5). Most *C. caudatula* were collected in the early evening, most of *C. costata* in the middle of the day, and so on. Comparing observed numbers with expected ones, it appears that *C. caudatula* was more frequent in the morning than was expected, whereas in *C. costata* the conclusion above is confirmed. If the data from all species are compared, species differ by daily activity.

### *Sympatry of species*

The four native species were reported from all parts of Switzerland and in all habitats in which collection was sufficiently intensive. The species appear to be sympatric in all these areas.

### *Local coexistence of species*

Usually two to four species were seen to coexist at the same place, sometimes even on the same spot. From a cut oak (*Quercus robur*) in a Midland forest, five drosophilid species were picked in a few days. They were *C. caudatula*, *C. distincta*, *C. fuscimana*, *Drosophila subobscura* and *Scaptomyza pallida*. However, such records are exceptional. Considering all 64 records from two years, 27 records yielded 1 *Chymomyza* species, 13 yielded 2 species, 16 yielded 3 species and 7 yielded 4 species. If computed from these data, the mean number of species per record is 2.05. However, unsuccessful collecting efforts are not considered here, which means that the class of zero species is lacking. Also, the time and effort spent on collecting was not the same in all records. Finally, the samples were obtained under variable conditions of the environment. Considering all this, computing a mean number of species is not warranted. As a guess it is closer to one than two.

Agonistic interactions between two flies were seen to involve the same or different species (Tab. 6). Loosely speaking, those species were associated. In a strict sense, however, association implies coexistence on a spot, or spots, more frequently than can be expected to occur randomly among species which share a given habitat. Association between species must be the result of a particular mechanism which could be, for instance, their mutual attraction.

### *Dissociation of species*

Instances of dissociation were prominent. As an example, over a month in spring of 1994, a total of 7 *C. fuscimana* were collected from a stack of logs in the Gockhausen forest. A little earlier, a total of 6 *C. caudatula* were collected at a site 200 m apart. Hence, the two species were spatially separated for about a month in spring. Yet by July they coexisted at another stack of small logs 200 m away in the same forest. Another instance of dissociation was noted in June 1994 in an alpine forest. Two out of three sites yielded only one *Chymomyza* species which was not the same at the two sites. The third site yielded two species, which however were spatially separated from each other by about 30 meters.



Tab. 5 – Numbers of flies collected at different daytimes: morning (from dawn to 10.30 h), mid-day (from 10.30 to 16.30 h), early evening (from 16.30 to 18.30 h), late evening (from 18.30 h to night). Contingency table chi-square = 42.18, d.f. = 9,  $p = 0.0001$ . From rounding expected numbers to the nearest integer, some marginal sums in the lower table deviate from corresponding sums in the upper table.

	<i>Chymomyza</i> <i>caudatula</i> <i>costata</i> <i>distincta</i> <i>fuscimana</i>				row sum
	<b>observed numbers</b>				
morning	23	7	10	52	92
mid-day	21	24	24	110	179
early evening	30	5	30	132	197
late evening	7	15	9	108	139
sum	81	51	73	402	607
	<b>expected numbers</b>				
morning	12	8	11	61	92
mid-day	24	15	22	119	180
early evening	26	17	24	130	197
late evening	19	12	17	92	140
sum	81	52	74	402	609

Tab. 6 – Six pairs of flies which were captured while they interacted.

interacting flies are	one fly	the other fly
of the same species	<i>distincta</i> ♂ <i>fuscimana</i> ♂	<i>distincta</i> ♂ <i>fuscimana</i> ♂
of different species	<i>caudatula</i> ♂ <i>caudatula</i> ♂ <i>distincta</i> ♂ <i>distincta</i> ♂	<i>fuscimana</i> ♂ <i>fuscimana</i> ♂ <i>costata</i> ♀ <i>fuscimana</i> ♂

Tab. 7 – Drosophilids other than *Chymomyza*, collected along with *Chymomyza* flies from trees in forests. In *D. subobscura* and *D. obscura* the predominance of males is remarkable.

	♀ ♀	♂ ♂
<i>Drosophila subobscura</i>	3	40
<i>obscura</i>	3	11
<i>subsilvestris</i>		1
<i>funnebris</i>		1
<i>immigrans</i>		1
<i>kuntzei</i>	1	
<i>Scaptomyza pallida</i>	8	6

*Aggregated dispersion within species*

In June 24, 1994, *C. fuscimana* flies were collected in a forest area above Tinizong where hundreds of trees had been cut. Out of 32 inspected cut ends, 28 yielded no fly, 3 yielded 1 fly each and one cut end yielded 5 flies. The census was repeated a month later in the same area. This time 73 cut ends were inspected. Out of them, 68 yielded no fly, 4 yielded 1 fly each and 1 cut end yielded 2 flies. The aggregations seem to follow the power law by Taylor (BURLA & BÄCHLI, 1993).

At the lower forest area above Tinizong, 19 *C. costata* flies were recorded in 1994 (Tab. 1). Of them, 17 were taken on a single tree stump out of 20 stumps which had been inspected on the evening of two consecutive days. Two more *C. costata* flies were from the nearest stump, 2 m apart from the other one. Incidentally, the two stumps were from spruce trees cut a year before. This anecdotal experience breaks the rule that only freshly damaged trees yield *Chymomyza* flies.

Uncommonly many *C. fuscimana* were observed on September 18, 1993 in the Gockhausen forest, on a small stack of thin logs which were 6 m long, the diameter varying between 10 and 27 cm. While a few *C. fuscimana* were seen on several logs, more than a hundred, if not hundreds, busily moved along a log on top of the stack. They moved in both directions, waving wings, and interacting whenever two met. There were various pairs in copula. Only very few flies were seen on the two cut ends of the same log, showing again that records from cut ends represent the respective populations incompletely. The particular log was 10 cm by diameter. Diminishing numbers of *C. fuscimana* flies could be seen on the stack until October 13. A restrained sample of 13 females and 43 males were taken from the crowds. During the same period of time, the density of *C. fuscimana* appeared to be higher than usual also on nearby stacks of spruce logs.

*The case of C. amoena*

During the present study only one specimen of *C. amoena* was captured. This was at knee level in the Gockhausen forest in spring 1993. Another specimen was seen in the Tinizong lumberyard to sneak from underneath a log on the floor. This fly escaped. All observations point to a clandestine life on the forest floor. The species was reared from black walnuts, acorns, chestnuts, sweet cherries, plums, pears, crabapples and domestic apples gathered from the ground (BAND, 1988a, 1995b; BURLA & BÄCHLI, 1992). Oviposition is predominantly on fallen fruits and nuts (BAND, 1988a). The species was also netted over mashed banana bait placed on the forest ground in various parts of the country including sites not far from Zurich and Tinizong (MACA & BÄCHLI, 1994). *C. amoena* not only breeds in forests but also in domestic habitats (BAND, 1995a, 1995b). The species' abundance is usually low in forests. It can be higher in domestic habitats (SCHUMANN, 1987). This may be due to mass reproduction in domestic media such as fallen domestic apples. Hence, *C. amoena* is a wild species in forests while domestic characteristics may appear in human environments.

*Other genera*

Species of *Drosophila* and *Scaptomyza* were collected along with *Chymomyza*, though in lower numbers (Tab. 7). Whereas in *Scaptomyza pallida* the sex ratio was balanced, most *Drosophila* flies collected from logs during the two years were males. In one case, 11 flies of *D. subobscura* were caught on a log in the Gock-

hausen forest and 11 flies of *D. obscura* on another log 20 m apart, suggesting species dissociation. In another case, a total of 14 *D. subobscura* flies were collected from a spruce stump in a forest near Gockhausen in the course of a week. All were males which occupied a small part of the stump surface for a long time. This lasted 30 minutes for one male before he was captured. These males as well as others, which seemed to be visitors, moved jerkily and waved wings, similar to, but less drastically than, lekking *Chymomyza* males. Thus three characteristics of *Chymomyza*, which are spatial dissociation between species, local aggregation of flies of each, as well as lekking behavior, may also be seen in *Drosophila*.

#### ZUSAMMENFASSUNG

In einem Waldrevier auf dem Adlisberg bei Zürich sowie in einem alpinen Hangwald oberhalb Tini-zong im Oberhalbstein, schliesslich auch in drei Graubündner Holzlagern, wurden im Sommer 1993 und 1994 *Chymomyza*-Arten gesucht. Vier autochthone Arten der Gattung, deren Vorkommen in der Schweiz schon bekannt ist, kamen in beiden Waldgebieten vor. Typischerweise wurden sie auf frisch gefällten Bäumen, auf deren Schnittstellen und Rindenverletzungen gesehen und einzeln mit Exhaustor oder Glasröhrchen abgefangen. Der Bericht über total 607 eingebrachte Fliegen wird detailliert nach Art, Fangort und Baumart, Jahreszeit und Tageszeit. Diskutiert werden Sympatrie, Assoziation und Dissoziation von Arten, Artunterschiede im makroskopisch sichtbaren Laufverhalten sowie das Vorkommen von Leks (Paarungsorte). Im Verein mit *Chymomyza* wurden mit der gleichen Methode 6 *Drosophila*-Arten und eine *Scaptomyza*-Art gefangen.

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