THE LIFE HISTORY OF *CALLIPHORA OCHRACEA* SCHINER (DIPTERA, CALLIPHORIDAE).

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(Two Text-figures.)

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1. *Introduction.*

The earliest reference to *Calliphora ochracea*, other than purely systematic, occurs in a pamphlet by W. W. Froggatt, published in 1914, in which he gives a coloured plate including this species, and states that nothing is known about its life history. In 1915 he noted, in another publication, that it appears to frequent shaded gullies and timbered country, but has never been found breeding in carcases or live sheep. He kept specimens in captivity in an attempt to induce them to oviposit on meat, but without success. Hardy, in 1926, also mentions the fact that no one has succeeded in breeding *Calliphora ochracea*, but in 1930 claims that it is a notorious blower of blankets. These facts seem difficult to reconcile.

Attempts to breed the fly here under insectary conditions having been successful, the present paper gives the life history and description of the various stages.

2. *Systematics and Synonymy.*

Calliphora ochracea Schiner is separated, along with the closely related *C. nigrithorax* Mall. from all other Australian species of *Calliphora* by the hairiness of the eyes. In general form it is also very distinctive, so that Brauer and Bergenstamm made it the type of a new genus *Neocalliphora*, and Surcouf later transferred it to the subgenus *Adichosia*.

Calliphora ochracea was described by Schiner in 1868 from females collected in Sydney. Macquart, in 1850, had described *Ochromyia hyalipennis* from a female from Tasmania. In 1914 Surcouf added further details to Macquart's description from the type females.

Johnston and Hardy, in 1922, placed the two species *ochracea* and *hyalipennis* in the genus *Neocalliphora* of Brauer and Bergenstamm. In 1925 Patton included the hairy-eyed blowflies in the genus *Calliphora*, and stated that *C. hyalipennis* Macq. is the well-known reddish-brown blowfly of Australia. He stated that the types of *hyalipennis* are typical specimens of *ochracea*, and so the former name must replace Schiner's.

Hardy, in 1926, also included all the species under *Calliphora* and pointed out the difference between the two species *hyalipennis* and *ochracea*. He noted Patton's sinking of *ochracea* as a synonym of *hyalipennis*, but the fact remains that two valid species occur; one in Tasmania and one on the mainland. Hardy

also pointed out in this paper that Macquart had used the name *hyalipennis* earlier for another species.

Malloch, in 1927, was of the opinion that the Tasmanian and mainland forms were distinct species, but owing to scantiness of material would come to no definite conclusion. He called the Tasmanian one *nigrithorax* and listed it as a form of *ochracea*.

In a paper published just previous to that of Malloch, Bezzi stated that he had a female of a species, which he called *Calliphora* (*Adichosia*) *hyalipennis* Macq. 1850, *nec* 1834, from Sydney, that it is recorded from Australia and Tasmania, and that *ochracea* Schiner is a synonym.

The descriptions of Macquart and Schiner, applied respectively to long series of *C. nigrithorax* and *C. ochracea* before me, leave no doubt as to the validity of these two species. With the exception of one female in the Australian Museum, all the *nigrithorax* are from Tasmania. This specimen, labelled Barrington Tops, N.S.W., appears to be the first record of the species from the mainland.

The work embodied in this paper was carried out on *Calliphora ochracea* Schiner.

3. *Distribution.*

According to all the records and collections, this species occurs along the coast and tablelands of New South Wales and Queensland. It does not appear to extend west of the Main Divide, and as far as I know there are no records of it from Victoria. The most northerly record noted is near Mackay, N.Q. Although there are few accounts of its occurrence south of Sydney, it has recently been collected at Pambula not far distant from the Victorian border, but farther south it was not seen.

Although it occurs right on the coast, *Calliphora ochracea* seems to be most abundant in elevated, timbered country. It has been collected by the writer at Sydney and Barrington Tops at the same time of the year, and the difference in abundance was very noticeable. So, although *C. ochracea* has been referred to as a somewhat rare blowfly, this is not true for certain localities where conditions are apparently most suitable for it. It has not been found in the Federal Capital Territory, this region being too far west and doubtless too dry for the species.

C. ochracea has an early spring and autumn cycle. The writer has taken it in numbers only in the early spring, at the end of July and in August, but a few odd specimens have been caught in certain localities in summer. The great majority in collections, however, are labelled March and April.

4. *Method of Breeding the Fly.*

In July and August, 1929, several females of *C. ochracea* were caught in company with *C. stygia* on the windows of a house in Northbridge, Sydney. It was decided to use such a favourable opportunity to try to discover some facts about its hitherto unknown life history. With this object in view two females were confined in a jar containing a piece of moistened meat wrapped in muslin. Jam was smeared on the side of the jar as food for the adults, which were observed to feed from this immediately. The top of the jar was covered with muslin. The following day one of the flies was observed ovipositing on the jar cover by thrusting the ovipositor right through the muslin and placing the eggs on the outside. Two days later the eggs hatched and both flies died.

On 7th August another female was put into a jar containing fresh beef wrapped in muslin and moistened with cabbage water. A piece of rabbit fur was placed on top of this. The fly was fed on sugar-water, jam and boiled sweets. Three days later it deposited a batch of eggs in the fur. The same evening the fly and the two jars were taken to Canberra. The same fly was given a jar in the blowfly insectary containing meat, muslin and fur. On 4th September it produced a fresh batch of eggs and died the next day. Since this particular fly had lived thirty days and oviposited twice since being captured, a note on the method of keeping it alive in captivity may be of interest. A comparatively large proportion of carbohydrate food seemed essential. It was observed to feed for quite long intervals on honey and jam, and although it was occasionally noticed sucking juices from the meat and cabbage, this food was definitely not sufficient to support it alone. Quite large pieces of sugar were absorbed by this fly at one meal, and it was found necessary to provide it with a fresh supply of such food each day. Each day it was released from the jar and allowed to fly round the insectary in the sunlight for a time.

At the end of August, 1930, a female was caught in Northbridge and brought to Canberra. It readily oviposited on rabbit fur placed on a piece of steak. This fly produced one batch of eggs only, and died in a few days.

Early in September, another female was received from the same locality. Five days later it produced a batch of eggs. The cold weather seemed to affect this fly seriously, but on removing it from the insectary to a constant temperature chamber at 23° C. it revived and, four days after producing the first mass of eggs, it oviposited again and died soon afterwards.

In every batch the larvae fed to full size on the decomposing beef present when the eggs were deposited.

When more than four hundred adults emerged from these last two batches every effort was made to induce this generation of flies to breed. It became evident that the heat and humidity of the constant temperature room suited them better than conditions in the insectary, doubtless approaching more closely their natural environment. They lived for lengthy periods under these conditions, feeding readily from the materials provided, including a variety of carbohydrate and nitrogenous foods. But mating was never observed, and females dissected at different periods showed no signs of egg development. Eventually, however, some eggs were deposited in fur but these failed to develop.

5. *Length of Stages in Life Cycle.*

The following observations were made on the flies bred in 1929. The eggs took two days to hatch. In Batch 1 the maggots hatched on 6th August and were still feeding on 29th. By 3rd September they were prepupal, on 16th the first puparium was seen, and on 20th several had pupated. The first emergence took place on 2nd November. In Batch 2 the maggots hatched on 12th August, and all, with the exception of some which appeared unhealthy, were prepupal on 20th September. Puparia were present on 27th, and on 28th October the first adults emerged. In Batch 3 the maggots hatched on 6th September. They increased in size very slowly and when six days old were not much larger than when hatched. In warm weather other species will grow to full size and pupate in this time. Obviously the cold weather during which it breeds retards the larval development of *ochracea*. During the next three days they increased noticeably in size. On 2nd October most of the maggots in this batch had disappeared into the sand

to pupate, and by 17th all had pupated. Ten adults emerged on 4th November. The last fly from these three batches died on 17th December.

The average larval life, that is the active feeding stage, was 30 days. The prepupal period occupied about 13 days, but the pupal period varied a good deal in duration. Those larvae which pupated early, that is about the middle of September, emerged at the same time as those which had not reached the pupal stage until the middle of October. The rapidity of development of the fly in the puparium was dependent on temperature, so that those which had pupated some time earlier than the others did not develop any more quickly owing to the cold weather. Thus there were flies emerging from all three batches at the same time in the first two weeks of November.

Altogether from the three batches of maggots produced by two females 74 flies emerged, 46 males and 26 females. In addition there were 60 dead prepupal maggots, 47 aborted puparia and 34 puparia containing dead flies. Thus on an average there were 72 eggs produced in each batch. The flies of this generation lived from four to six weeks in the insectary, but with one exception did not oviposit. One female laid eggs on a guinea pig. They were attached close to the skin on the hairs, were very pale in colour and did not hatch.

6. *Effect of Temperature and Humidity on Rate of Development.*

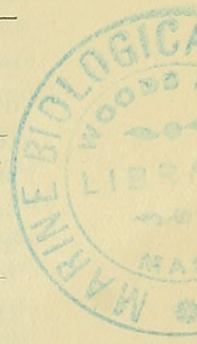
Since the rate of development of *C. ochracea* is slower than most blowflies, an experiment was carried out to see if this is correlated with the low temperature conditions of the season during which it breeds.

A batch of eggs produced on 28th August, 1930, was divided into two lots; one lot was kept in the insectary and the other in a higher temperature chamber. The developing maggots were kept under close observation and a record of the dates at which they reached the various stages made for comparison. There was a striking difference in the maggots of the two batches after four days. Those in the insectary were a few millimetres long, whilst those in the warm room were in their third instar.

The temperature in the warm room, except for very slight fluctuations, remained at 23° C. during the whole period. The humidity was higher than that in the insectary, but varied somewhat. It was always above 70% and generally between 70% and 80%. The insectary temperature was not controlled and fluctuated considerably, becoming higher as the season advanced. The minimum ranged from −1·6° to 9° C. in September and reached 11° C. in October. The maximum rose from 12° to 31° C. whilst the fly was breeding.

A comparison of the periods of development in the two cases is as follows:

	Constant Temp. Room.	Insectary.
Egg to end of third instar (feeding stage) ..	4 days	27 days
Prepupal stage	5 days	12 days
Pupal stage	16 days	21 days
Total period from egg to adult	25 days	60 days



So marked was the effect of temperature and humidity on development that adults were present under warm, moist conditions, whilst maggots from the same batch of eggs were still feeding under normal outdoor conditions. The difference in the length of the larval stage was the most pronounced, that in the prepupal stage less so, whilst that in the pupal stage was the slightest. This was no doubt partially due to the fact that the insectary temperature was increasing as the weeks passed.

The adults also live longer and are more vigorous under warmer, moister conditions than the normal Canberra climate. Flies kept in the insectary died in a few days. Those in the constant temperature room lived from four to six weeks. A female kept in the insectary took 25 days to mature a second batch of eggs, whilst one in the warm room produced two batches within five days. In the latter case there were more than 200 eggs in each batch, and in the former there were only about 75. Moreover, the progeny of the second female had completed their life cycle in 24 days, whilst those of first took more than two months.

7. *Description of the Early Stages.*

(*a*) *The Egg.*—The egg is 2·5 mm. in length. It is creamy in colour. The shape is a long ellipse, slightly curved and narrowed and flattened at the micropylar end. In eggs which are near to hatching the young maggot can be seen shrunken away from the transparent chorion and with the pointed head towards the micropylar end.

(*b*) *First Stage Larva.*—The maggot at this stage is 4 mm. long. It is sharply pointed at the head end, and broad and truncated posteriorly. The maggot has a pseudocephalon, three thoracic, and eight normal and two very reduced abdominal segments. The head is divided, as in all blowfly larvae, into two distinct lobes, each bearing a maxillary palp and a small papillate antenna on the dorsal surface. There are two well-marked but unbranched oral grooves present. The two lateral hooks of the bucco-pharyngeal armature are strongly chitinized and conspicuous.

The anterior border of the first thoracic segment bears a row of strongly chitinized black spines which are short, stout and closely set all round the margin. They are smaller and less heavily chitinized on the dorsal surface. This segment sheathes round the head and has a slightly bilobed flap projecting forward. In this region it bears several sinuous rows of small dark spines more or less projected backwards, and becoming smaller in the more posterior rows. The second and third thoracic segments have a couple of rows of spines on the anterior borders all round, and these are more chitinized and conspicuous on the ventral surface.

Each abdominal segment also bears rows of spines on the anterior border. These widen out on the ventral median surface to several rows where they form a distinct patch behind the junction of each segment. Unlike the other segments the first abdominal segment has in place of the lozenge-shaped area two rows of spines. Towards the middle of each lozenge-shaped spiny area there is a clear space devoid of spines. This space is placed slightly posteriorly, that is, there are about five rows of spines in front of the clear space and two behind, so that it does not lie in the centre of the spiny area. The posterior rows of spines are the largest and most heavily chitinized and are directed backwards. The spiny areas project downwards making a ventral bulge on each segment.

The posterior spiracles are in the form of dorsal stigmatic plates on the eighth abdominal segment. They are very pale and seem to be hardly more chitinized than the skin of the larva. Two slits are present, which are short, wide and close together. The felt chambers are noticeable through the thin skin, and the tracheal trunks can be seen from the dorsal surface diverging as they pass inwards. There are no other spiracles present in the larva at this stage.

(*c*) *Second Stage Larva.*—The following description is from a larva ten days old. The two-lobed structure of the head and the antenna and maxillary palp are the same as in the previous stage. The lateral hooks are both the same size and bear small thin spines.

The anterior border of the three thoracic segments has very small and inconspicuous spines. Ventrally at the anterior margin each of the abdominal segments bears a wide band of rows of small spines directed backwards. They form a band right across the ventral surface instead of a median patch as in the previous stage larva. The clear space towards the centre is, however, still present.

As in the first-stage maggot the spiny bands from a lateral view appear as distinct swellings on the ventral surface of the abdominal segments. Dorsally the band is not as wide or conspicuous as on the ventral surface. It is distinguishable on the first four segments and then fades away, and is again noticeable on the last four. On the ninth segment ventrally there are two large projections, and the anus, representing the tenth segment, is situated between and a little behind these. The posterior spiracles are in a hollow on the dorsal surface of the eighth segment. The plate bears two slits which are short and wide with chitinous sinuous edges, and the outside slit has a distinct bend in the centre. The peritreme or chitinous border of the plate is very thin and inconspicuous. There are six papillae round the edge of the hollow, behind the spiracles and beneath them. These papillae form the most posterior extremity of the maggot, projecting backwards over the last two segments.

One maggot was killed and preserved just at the ecdysis between the second and third instars. The body of the maggot had shrunk away from the last two segments of the previous skin leaving it quite transparent, so that the old spiracular plates with two slits were plainly visible. The new posterior spiracular plates were seen on the new maggot through the transparent old skin. They were faint and not chitinized, being the same colour as the skin of the maggot. The three slits, however, were distinct and plainly visible.

(*d*) *Third Stage Larva.*—The following description is from a larva nineteen days old. The full-grown maggot is 16 mm. in length. The head is relatively much smaller than in the previous instars, having not increased in the same proportion as the rest of the body. The first thoracic segment overlaps the head slightly on the dorsal surface and is very spiny at this point. The anterior spiracles are conspicuous on the first segment of the thorax and are fan-like, ending in nine papillae. The general structure of the maggot is similar to those already described. The body segments are well marked, more swollen and annulated at the junctions than in previous instars. The junctions are marked by bands of spines, which are most numerous and conspicuous on the ventral surface where the band widens. The last four large abdominal segments have the junctions less swollen, especially dorsally where there is practically no annulation.

The posterior spiracles lie in a deep hollow on the dorsal surface of the eighth segment. There are six little papillae on the anterior dorsal rim of this hollow, and two outer larger and two inner smaller ones on the posterior lower margin.

Two more papillae are situated outside and below these, but also on the rim of the depression. Below this depression there is a ventral protrusion, the ninth segment, which is covered with small spines above and has the anal opening in the middle.

Spines are present around the lower edge of this also. The ninth segment bears a pair of large papillae, one on each side of the anus projecting laterally.

Posterior Spiracles.—The distance between the spiracular plates is, on an average, 0·27 mm. The general conformation and structure of the spiracles is typically Calliphorine, being very similar to that of all other Calliphoras examined. The plates are almost round in outline but slightly projecting at the button or external scar, and showing a slight scalloping or bulging where the upper end of the slit reaches the peritreme. The peritreme is strongly chitinized, but not very wide, and has inward projections between the slits. The button is completely enclosed in the peritreme.

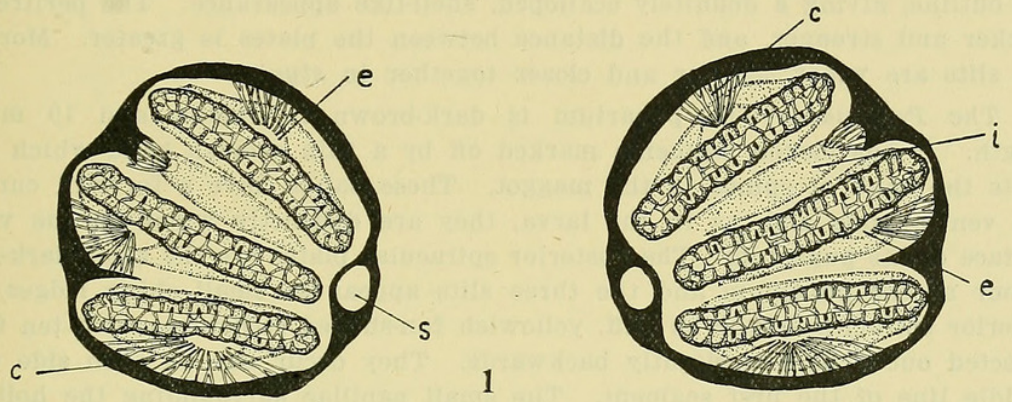
The three slits are narrow and elongated, running the full length of the plate, and making bulges in the peritreme at their upper ends. The slits are equal distances apart at their bases near the button. They diverge from here, but are still about equal distances apart at the apex near the peritreme. The lower or outer slit is a little shorter than the other two and has a slight curve upwards at the middle. The middle slit curves downwards at the centre, and the upper or inner one curves upwards. Thus there is a space between the inner and middle slits which is occupied by the "intermediate structure" of Froggatt, whilst the outer and middle slits come close together at the middle. The lower slit runs straight outwards, whilst the other two run outwards and upwards.

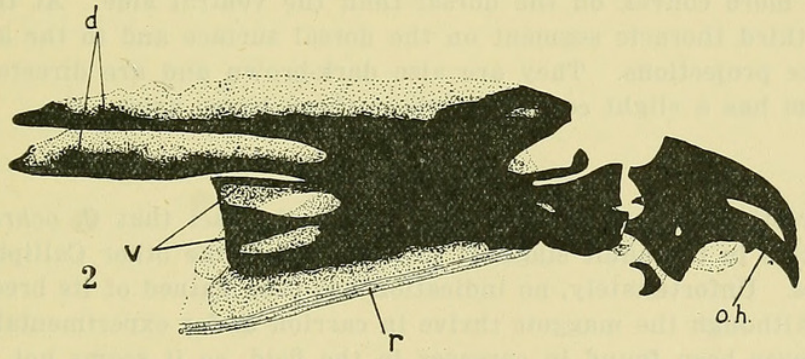
There are four openings of perispiracular glands. These are in the form of small round, clear spaces. One is situated on the top of the "intermediate structure", between the inner and middle slits, one is on the upper margin of the inner slit at its middle, one is on the lower margin of the middle slit towards its outer end, and the fourth is on the lower margin of the outer slit about its middle. From the openings of the perispiracular glands a series of fine, chitinous hairs radiates in a fan-shaped fashion, reaching the peritreme. In most preparations these appear as lines on the ground membrane of the spiracular plate and are referred to by Froggatt as "sun-ray effects". The slits bear thick chitinous borders which are sinuous or scalloped, leaving only a narrow cleft down the centre of the slit which is crossed by a network of chitinous bars running from one border to the other. The peritreme is paler round and near the button. The inward projection of the peritreme between the middle and inner slits is often bifid, one point running each side of the perispiracular gland opening in this situation.

Some features of the spiracles are variable. There is practically no inward projection of the peritreme between the slits in some cases, and occasionally the slits do not run the full length of the plate and cause bulges in the peritreme, but end short with quite a space between their upper ends and the peritreme. The shape of the slits and other features are constant.

Anterior Spiracles.—The tracheal trunk ends in a wide felt chamber which terminates in a variable number of short papillae, from nine to eleven in most cases, but one example had only eight. They are well separated from each other, and the openings at the ends of each are large, with thick chitinous rims. The papillae spread out in a fan-like manner, and in the specimen with eight only they were farther apart and more spread out than usual. The top of the felt chamber just below the papillae has numerous large, clear spaces in it.

Buccopharyngeal Armature.—The pharyngeal sclerite is similar to that of all other Calliphorine larvae examined. There is the usual deep incision in the posterior end, and the dorsal cornua are long and have the inner edges very strongly chitinized. The ventral cornua also have the inner edges most heavily chitinized. Along the ventral margin of this sclerite runs the ribbed ventral wall of the pharynx. According to Keilin, this feature is characteristic of all Cyclorrhaphous dipterous larvae which are saprophagous. At the anterior end of the pharyngeal sclerite there is a pair of narrow chitinous rods projecting forwards from it, and with the ends hooked sharply upwards like a ladle.





Text-fig. 1.—Posterior spiracles of third stage larva of *C. ochracea.* × 95. *c*, chitinous hairs; *e*, external opening of perispiracular glands; *i*, "intermediate structure"; *s*, external scar.

Text-fig. 2.—Buccopharyngeal armature of third stage larva of *C. ochracea.* × 42½. *d*, dorsal cornua; *o.h.*, oral hooks; *r*, longitudinal ridges; *v*, ventral cornua.

The middle or hypopharyngeal sclerite is very heavily chitinized and articulated posteriorly with the pharyngeal sclerite and anteriorly with the base of the oral hooks. This sclerite is small, the whole armature being narrowest at this point. The oral hooks are very chitinous and black, with wide triangular bases which have a small hole in the centre. The hooks are of equal length, long and pointed. There is a short chitinous rod, wider at the posterior end, projecting forwards between the oral hooks. Ventrally, at the base of each hook there is a small thick, crescent-shaped sclerite, heavily chitinized, with the posterior horn narrowing to a tail. In the ventral curve of the hooks, projecting ventrally, there is a pair of yellowish, lightly-chitinized, curved disc-like structures, which are behind the median rod.

The maggot of *C. ochracea* is a typical *Calliphora* larva. On comparing it with the maggot of *C. stygia* they are found to be remarkably similar in detail. The only real distinction lies in the spiracles. *C. stygia* has more papillae in the anterior spiracles, usually twelve. These are longer and narrower than in *ochracea*, and the whole structure is larger and more robust. The posterior spiracles, however, offer the most reliable distinguishing characters. In *C. ochracea* the plates are almost round, and in *stygia* they are elongated at right angles to the slits, becoming broadly pyriform. Also in *stygia* they possess strong projections of the peritreme between the slits and corresponding concavities in the outline, giving a definitely scalloped, shell-like appearance. The peritreme is thicker and stronger, and the distance between the plates is greater. Moreover, the slits are wider, shorter and closer together in *stygia*.

The Puparium.—The puparium is dark-brown in colour, and 10 mm. in length. It has eleven segments marked off by a thin greyish band which represents the band of spines in the maggot. These bands have a forward curve on the ventral side and, as in the larva, they are distinctly wider on the ventral surface of the puparium. The posterior spiracular plates are the same dark-brown colour as the puparium and the three slits appear as small shiny ridges. The anterior spiracles appear as stiff, yellowish fan-shaped structures with ten fingers directed outwards and slightly backwards. They occur one on each side of the middle line of the first segment. The small papillae surrounding the hollow in which the posterior spiracles lay are still present as small hard projections. The puparium is more convex on the dorsal than the ventral side. At the posterior edge of the third thoracic segment on the dorsal surface and to the side are two tiny horn-like projections. They are also dark-brown and are directed forwards. The puparium has a slight concavity where these horns arise.

8. *Conclusion.*

An interesting feature of this work lies in the fact that *C. ochracea*, whilst very distinctive in the adult stage, is so remarkably like other Calliphoras in the earlier stages. Unfortunately, no indication has been gained of its breeding habits in nature. Although the maggots thrive in carrion under experimental conditions, they have never been found in carcases in the field, so it seems not unlikely, as the flies readily oviposit in thick fur, that they are restricted to the dead bodies of some particular native animal. Thus similarity in the larval environment to that of other Calliphoras may account for the identity of the maggots, the adult environment and habits being different from other species.

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