FISHERIES RESEARCH BOARD OF CANADA

Translation Series No. 2530

# Apolyclad (Stylochus Pilidium Lang) harmful to oyster beds

Hans Bytinski-Salz

Original title: Un policlado (Stylochus Pilidium Lang) dannoso ai parchi ostricoli

From: Thalassia (Rivista dell'Istituto Italo-Germanico di Biologia Marina de Rovigno d'Istria)(Thalassia (Revue of the Italo-Germanic Institute of Marine Biology of Rovigno d'Istria, Italy), II(1), : 1-24, 1935

Translated by the Translation Bureau(MMM)
Foreign Languages Division
Department of the Secretary of State of Canada

Department of the Environment
Fisheries Research Board of Canada
Marine Ecology Laboratory
Dartmouth, N. S.

1973

35 pages typescript

FRB 2530

DEPARTMENT OF THE SECRETARY OF STATE
TRANSLATION BUREAU
MULTILINGUAL SERVICES DIVISION

CANADA

SECRÉTARIAT D'ÉTAT
BUREAU DES TRADUCTIONS
DIVISION DES SERVICES MULTILINGUES

| TRANSLATED FROM – TRADUCTION DE | INTO – EN |
|---|---|
| Italian | English |

AUTHOR – AUTEUR

Hans BYTINSKI-SALZ

TITLE IN ENGLISH – TITRE ANGLAIS

A Polyclad (Stylochus Pilidium Lang) harmful to oyster beds.

TITLE IN FOREIGN LANGUAGE (TRANSLITERATE FOREIGN CHARACTERS)
TITRE EN LANGUE ÉTRANGÈRE (TRANSCRIRE EN CARACTÈRES ROMAINS)

Un Policlado (STYLOCHUS PILIDIUM Lang) dannoso ai parchi ostricoli.

REFERENCE IN FOREIGN LANGUAGE (NAME OF BOOK OR PUBLICATION) IN FULL. TRANSLITERATE FOREIGN CHARACTERS.
RÉFÉRENCE EN LANGUE ÉTRANGÈRE (NOM DU LIVRE OU PUBLICATION), AU COMPLET, TRANSCRIRE EN CARACTÈRES ROMAINS.

THALASSIA (Rivista dell'Istituto Italo-Germanico di Biologia Marina di Rovigno d'Istria).

REFERENCE IN ENGLISH – RÉFÉRENCE EN ANGLAIS

THALASSIA (Revue of the Italo-Germanic Institute of Marine Biology of Rovigno d'Istria, Italy).

| PUBLISHER – ÉDITEUR | DATE OF PUBLICATION / DATE DE PUBLICATION | | | PAGE NUMBERS IN ORIGINAL / NUMÉROS DES PAGES DANS L'ORIGINAL |
|---|---|---|---|---|
| Carlo Ferrari | YEAR / ANNÉE | VOLUME | ISSUE NO. / NUMÉRO | 1-24 |
| PLACE OF PUBLICATION / LIEU DE PUBLICATION: Venice, Italy. | | | | NUMBER OF TYPED PAGES / NOMBRE DE PAGES DACTYLOGRAPHIÉES |
| | 1935 | II | 1 | 35 |

REQUESTING DEPARTMENT / MINISTÈRE-CLIENT: Environment

TRANSLATION BUREAU NO. / NOTRE DOSSIER N°: ~~407096~~ 143864

BRANCH OR DIVISION / DIRECTION OU DIVISION: Fisheries Service/Office of the Editor

TRANSLATOR (INITIALS) / TRADUCTEUR (INITIALES): MMM

PERSON REQUESTING / DEMANDÉ PAR: Not stated

YOUR NUMBER / VOTRE DOSSIER N°: Not stated

DATE OF REQUEST / DATE DE LA DEMANDE: 2nd March, 1973.

APR 30 1973
UNEDITED TRANSLATION
For information only
TRADUCTION NON REVISEE
Information seulement

SOS-200-10-6 (REV. 2/68)
7530-21-029-5333

DEPARTMENT OF THE SECRETARY OF STATE
TRANSLATION BUREAU

MULTILINGUAL SERVICES DIVISION

CANADA

SECRÉTARIAT D'ÉTAT
BUREAU DES TRADUCTIONS

DIVISION DES SERVICES MULTILINGUES

| CLIENT'S NO. Nº DU CLIENT | DEPARTMENT MINISTÈRE | DIVISION/BRANCH DIVISION/DIRECTION | CITY VILLE |
| --- | --- | --- | --- |
| | Environment | Fisheries Services/ Office of the Editor | Ottawa |
| **BUREAU NO. Nº DU BUREAU** | **LANGUAGE LANGUE** | **TRANSLATOR (INITIALS) TRADUCTEUR (INITIALES)** | |
| 143864 | Italian | MMM | APR 30 1973 |

# A Polyclad (Stylochus Pilidium Lang) harmful to oyster beds

(with 3 figures in the text and 3 tables)

by

Hans Bytinski-Salz

(Rovigno d'Istria)

## Introduction and previous observations

The owner (1) of the oyster establishment of the Canal di Leme told me in July, 1934 of the serious losses suffered by young oysters born during the year, following the appearance of a great number of planarians. Upon making an on the spot investigation we were able to observe on the rafts set with young oysters, large quantities of Stylochus pilidium Lang, a polyclad turbellarian. At first it appeared to us that the young oysters had been attacked because they were already dead or weakened, on account of the abnormal hydrographic conditions which occurred in 1934, an extraordinarily rainy year, but in fact the first observations in the laboratory showed us, that the oyster had actually

---

(1) I am very grateful to Captain G. Morena, both for the help given me by his employees during my work in the oyster beds, and for the information on oyster production of previous years.

been attacked by the planarian.

Up to now there are only 3 publications in the literature on the damage caused to oysters by the planarian, relating to Australia, North America and Japan; the present case is the first occurring in Europe.

Lo Staed (1907) informed us of the appearance of Leptoplana australis on the oyster beds of Kingston, Bar and Pelican Island, along the coasts of New South Wales. This planarian, called (the) "wafer" by the local people, is found in great quantities on the oysters living in the zone bounded by high and low tide; the great number of open and empty shells served to show the destruction caused by the flatworms, some of which were also found in oysters which were still alive. Damage had already been caused before 1907, but then diminished only to increase once again in 1907 and then drop once more.

In 1919 Danglade gave us information of a flatworm invasion which occurred in the oyster beds on the coasts of Florida; but previously at the end of the 19th century near Indian River, along the eastern coast of Florida, a flatworm known locally as a "leech", was observed which, after several years of dormancy, reappeared en masse in 1917. In 1916-17 the beds of the western coast of Florida, from Tampa as far as Cedar Keys were attacked by a turbellarian, described by Palombi (1931) as a new species called Stylochus inimicus. It attacks both young and adult oysters and completely devours them. Once the flatworm has penetrated the oyster it still takes some time to overcome it; Danglade says, in fact, that the oysters seek to defend themselves by secreting a shell-like substance. In such cases the flatworm takes several days to kill the oyster and it is quite possible that it lives for a certain time as a parasite, feeding itself, according to the author, on the juices of the mollusc. The flatworm is usually found in the right portion of the oyster between the adductor muscle and the anterior portion situated close to the heart. The oyster can also be weakened by the juices secreted by the parasite.

The losses of adult oysters amounted, in the various oyster beds from 10% to 100%. The attack reached its peak in the summer and autumn of 1916; from 1 to 3 flatworms were found in each adult oyster, and on rare occasions 10. In February 1917, however, the number of parasites was much reduced; in 20 barrels of oysters only one or two of them were found.

Dr. W. C. Coe (of) New Haven, (Connecticut, U.S.A.) recently informed me that also along the coasts of Connecticut in certain years in the spring time, great quantities of Stylochus ellipticus Verrill amidst Balani are found, and young dead and dying oysters. The same thing has been observed along the coast of California.

Finally, we report what Bock (1925) wrote in a note on a new species of Stylochus (ferox in literature) discovered in Japan: "This species I shall call ferox, as it is a voracious animal, appearing as a destroyer of young oysters". Unfortunately we were given no further information on the biology of the species by this author.

The Leme Canal, situated 5 kilometers north of Rovigno, forms the submarine fluvial continuation of the Draga Valley (Yugoslavia); it is 11 kilometres long and cuts, in an E-W direction the Carso upland plain, which rises to about 100 metres. In the middle it is approximately 500 metres wide. It is bordered by rocky peaked walls and even only a few metres from the coast it has a depth of 10-15 metres. The greatest depths are found at the mouth of the Canal (30-35 metres), and near the oyster beds, situated at approximately 1500 metres from the end of the Canal, there are depths of approximately 20 metres. The banks are indented by numerous narrow inlets, fairly deep (approximately 15 metres), called valleys; close to the land there are flat banks and here, sheltered from the waves, the oyster grounds are situated.

The valley is closed off by a steel cable, supported in the water by a series of iron buoys, carring esparto grass strings (latticed) of approximately 3 metres in length, upon which the oysters are set. If the valley is broad there are even up to 3-4 rows of buoys. To collect the larvae small branches of Quercus robur, 20-25 centimetres long and an inch in thickness are placed in the water (table 1, fig. 4). The young oysters grow there rapidly and within the year reach a diameter of approximately 6 centimetres. The following summer the stakes together with the oysters are removed from the strings, which have rotted in the meantime and are fixed to new strings. The oysters, which come off during the operation are cemented four by four onto small cement cylinders, approximately 5 centimetres long, which after they have dried out are threaded, like the stakes, onto strings and immersed in the water. The majority of the oysters reach, by the autumn, a size of 8 to 10 centimetres and become marketable. The oysters which have not yet developed are set aside and, in the spring time, suspended from new strings; thus during the summer, they reach a third period of development.

Given the breeding system, two facts appear which can be taken advantage of in the fight against the planarians:

1. The lattices hang freely in the water, and thus cannot come into contact with the bottom;
2. The oysters can easily be removed from the water and taken elsewhere.

The hydrographic conditions of the Leme Canal correspond with those which Gaarder (1933), Amemiya (1926) and other authors indicated as being favourable to the biology of oysters. The thermo-saline trend, which we obtained from thermal and salinity measurements carried out in 1927-28 in the oyster beds and kindly given to me by Dr. A. Vatova, are the following:

The temperature (Table II T.) in the layers from 2.5 to 5 metres, where in fact, the oysters live show a summer maximum of 25.52$^{o}$ Centigrade in July and a winter minimum of 10.08$^{o}$ Centigrade in February. From May to the first part of November a higher temperature of 17$^{o}$ Centigrade predominates, which is favourable to the development both of the larvae and of the very young oysters (Mazzarelli, 1923). In the same period the salinity is 35$^{o}$/oo, that is, well above the minimum necessary for the development of the oysters which, according to Gaarder, is 24$^{o}$/oo. The salinity is optimal or at least good even in the period of the greatest development of the oysters, that is from April to November, since according to Amemiya's data, regarding English oysters, salinity of 31-35$^{o}$/oo is optimal and 36-38$^{o}$/oo good. For Mediterranean oysters the optimum should be higher than 35$^{o}$/oo.

In the open sea (one mile offshore from Rovigno; the average for the five-year period 1921-25), according to Vatova (1933) the salinity, which fluctuates at around 38$^{o}$/oo, diminishes in the summer months and increases in the winter months. In the oyster beds, however, it has 2 minimum levels and its trend is exceedingly complicated; we must therefore indulge in further explanations. In the Leme Canal, on account of the special hydrographic conditions of the Carso upland plain, numerous fresh water springs, whose flow is closely related to atmospheric precipitations, have their outlets at sea level or slightly below sea level. Some streams are copious after heavy rainfall and dry up in the summer; others flow throughout the year, but at varying rates. Still others, situated in the zone between high and low tide and therefore slightly brackish, vary in salinity both on account of the tides and the intensity of the precipitations. The streams are especially numerous in the last stretch of the Canal, at approximately 500-800 metres after the oyster beds. The spring water mingles on the surface with the sea water and thus periodically forms a low salinity surface layer, which at times can even reach further than half way up the Canal. Table II shows the atmospheric precipitations at Rovigno, 8 kilometres away and the salinity observed in the Leme Canal in the oyster beds at depths of 0.5; 2.5-5; 13-15 metres. The curves, however, represent only very approximately the ratios existing in fact, since while the atmospheric precipitations were registered daily, the hydrographic observations were, on the other hand, carried out only once a month. In reality the curves should have a much more irregular trend and the minimum levels should be more accentuated.

However, a comparison between surface salinity and the quantity of atmospheric precipitations, shows that after heavy rainfall the salinity is low; thus, for example, from 17 to 31 January with 50.2 mm. of precipitation there is a minimum of 36.36$^{o}$/oo; from 2 to 29 March with 158.4 mm. a minimum of 13.96 $^{o}$/oo! (Sic) on 29th March; from 8 to 12 September with 46.9 mm. a minimum of 32.27$^{o}$/oo on 11th September; from 8th October to 24th November with 118 mm. a minimum of 20.81$^{o}$/oo on 24th November. The two low salinities of July and August (34.65$^{o}$/oo and 34.13$^{o}$/oo) which were not accompanied by heavy precipitations were at least in part due to the summer rise in temperature. It must also be noted that the salinity of the open sea is never reached at the surface and this is due to the constant influx of the fresh-water streams.

The lowest salinity observed in 1927-28, was found along the southern bank of the Canal towards Cul di Leme opposite the streams, that is to say, outside the oyster beds. In that zone on 29th March, 1928 there was a salinity level of 2.09$^{o}$/oo on the surface but already a level of 37.40$^{o}$/oo at a depth of 4 metres. The surface water, therefore, slowly prenetrates the deeper layers and diminishes their salinity; thus, for example, on 29th March the minimum salinity of 13.96$^{o}$/oo on the surface is accompanied, with characteristic delay (19.4), by a salintiy of 31.65°/oo at 2.5 metres. Even at a depth of 13 metres it was possible at the same time to establish the influence, even if only slight, of the fresh water with salinity of 37.18°/oo.

The salinity on the bottom generally differs very little from that of the open sea. In 1927-28 the highest salinity was observed towards the middle of the Canal (St. SA 9β) at a depth of 10 metres with 38.68°/oo.

Few data exist on the oxygen content of the waters close to the oyster beds: (those) from September 1927 to April 1928. The $O_2$ content fluctuates at the surface from 4.96 gr. $O_2$/litre to 6.43 gr. $O_2$/litre, on the bottom from 4.41 gr. $O_2$/litre, to 6.44 gr. $O_2$/litre, data which correspond to a relative quantity in oxygen of 98.6% and 107.88%, respectively of 80.9% and 102.72%. The water of the Leme Canal can thus be considered as saturated with oxygen at least in the surface layers.

From November 1927 to April 1928 alkalinity determinations were also carried out, by means of a solution of p. nitrophenol and the data thus obtained had the salinity error corrected. The pH values for the surface and the bottom near the oyster beds fluctuate between 7.70 and 8.07; the highest were observed at the mouth of the Canal (St. $SA_2$ of 7th August) with PH = 8.35 at the surface. The alkalinity therefore varies very little and is close to the values given by Gaarder (pH = around 7), which encourages the development of the larvae of the oysters of the

North; in all cases they are far from the maximum pH = 9. It is this alkalinity which in the North coincides with the mass development of the blue-green algae, which serve as food for the larvae, a very interesting fact.

The temperature and salinity measurements carried out on 11th August, 1934 correspond well with the data of 1927-28. A simple comparison of the salinity curve (Table II) at a depth of 2.5 metres which directly concerns the oyster beds, with the resistance of the oysters and the planarians in solution at a different degree of salinity (Table III), indeed shows us that over the entire year the tolerance limit is not exceeded. Low salinities, harmful to oysters occur at the surface only a few days per year and also in rest periods (winter and spring). If the salinity drops at the surface over broad areas and for long periods of time to less than $20^{o}$/oo, destruction of the planarians can occur.

## Biology of the Planarians

The Stylochus pilidium Lang, 1884 is a polyclad Turbellarian oval-oblong in shape, of a length of up to 7.5 centimetres, its colour is a dirty brown, and the edge is transparent and slightly wavy (Fig. 1). The surface is thickly strewn with small brown spots, arranged in ray- or halo-like fashion towards the periphery. Along the median line the pharynx is clearly seen in the form of a whitish spot; the lighter area lying in front of it is the cerebral ganglion; to the left and right there is a group of ocular spots (Fig. 2A). Anteriorly two prolonged tentacles extend which bear a series of eyes (Ta) on their distal half. The edge also is strewn with eyes (Ra), which although very thick in the anterior part, are somewhat rare but nevertheless not lacking in the posterior portion. It is distinguished from the Stylochus neoplitanus (Delle Chiaje), a species which is very similar, on account of the ovaries which lie dorsally in relation to the intestine. The Stylochus pilidium, contrary to other European species of Stylochus (perhaps with the exception of St. Flevensis Hofker 1930), has a larval form, the so-called Götte larva.

In the summer the planarian grows rapidly; at the end of July it reaches a size of 12-20 mm. and is already sexually mature; specimens bigger than 25 mm. were not observed. Halfway through October, very large specimens of 30-50 mm. almost exclusively, are found; only 15% were less than 30 mm.

In Naples (Castello dell'Uovo) the flatworm lives, according to Lang (1884), under rocks, whilst in the Leme Canal, at least up to the present time, it is always associated with oysters. It lies concealed for the most part on the lattices covered with oysters, rarely between the folds of the string. Its preferred dwelling is inside the empty oysters and in the fissures between the oysters, but it also crawls freely around them. The planarian has a strikingly negative phototaxis: placed under light it immediately seeks a dark corner and can in this case crawl rapidly (6-8 centimetres/minute at 20° Centigrade). Normally, however, it is very lazy; it can also slither along the surface of the water but it cannot swim.

The Stylochus forms a part of the epifauna of the oyster beds; particularly associated with the sedentary organisms are algae, Bryozoa and hydroid polyps; Spirographis, Tethium plicatum and Clavellina are rare. The epifauna is especially inhabited by Polychaeta and by two decapods: Pilumnus hirtellus L. and Porcellana longicornis Penn; the Thysanozoon Brocchi Grube appears very rarely.

In the environment in which it lives, the Stylochus does not appear to have enemies. The two above-named decapods do not attack it even if they are hungry; it probably defends itself against enemies by means of a secretion.

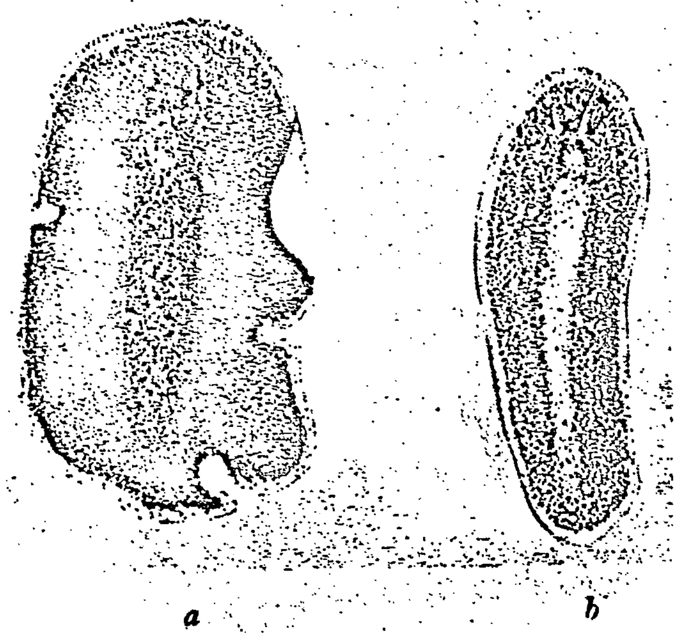



Fig. 1: Stylochus pilidium Lang: a) big brown specimen in repose;
b) smaller white specimen, crawling actual size.

What the planarian feeds on when it is free is not known. In the aquarium it did not use colonies of hydroid polyps (Clava spec.?), which are found on the oysters at the end of the autumn, as food. In the oyster beds, on the other hand, it devours the young oysters and also in small quantities, young Mytilus galloprovincialis Lamark.

On one occasion only we had the opportunity of observing how the planarian penetrates oysters. At a temperature of 20°C oysters, according to Galtsoff (1928), are always open, and this is the case in the Leme Canal during the whole of the summer until well into October. By taking certain precautions, it is possible to introduce a hair quite deeply between the valves in an open oyster without these closing. Lightly touching the peripheral tentacles of the edge of the mantle, which contract at the point touched, it seems, does not cause the closing of the shell. The flatworm in question was approximately 2 centimetres long and on 18th August at 9.00 O'clock P.M. it slipped by its right edge between the valves of an oyster 2.1 centimetres in size and after 20 seconds it had disappeared. When approximately 1/10 of the left edge of the flatworm was still protruding, the oyster made some attempts to close itself, but the flatworm was nevertheless successful in drawing itself inside. The following morning the oyster was dead; the valves were open and the flatworm was inside. In spite of numerous attempts it was not possible for us to observe just how the oyster was devoured.

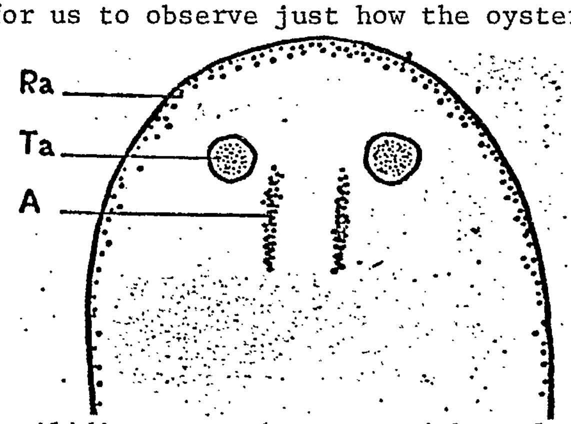



Fig. 2: Stylochus pilidium, anterior part with ocular spots; enlarged 3.5 X times. A. cerebral eyes, Ta. tentacular eyes, Ra. marginal eyes.

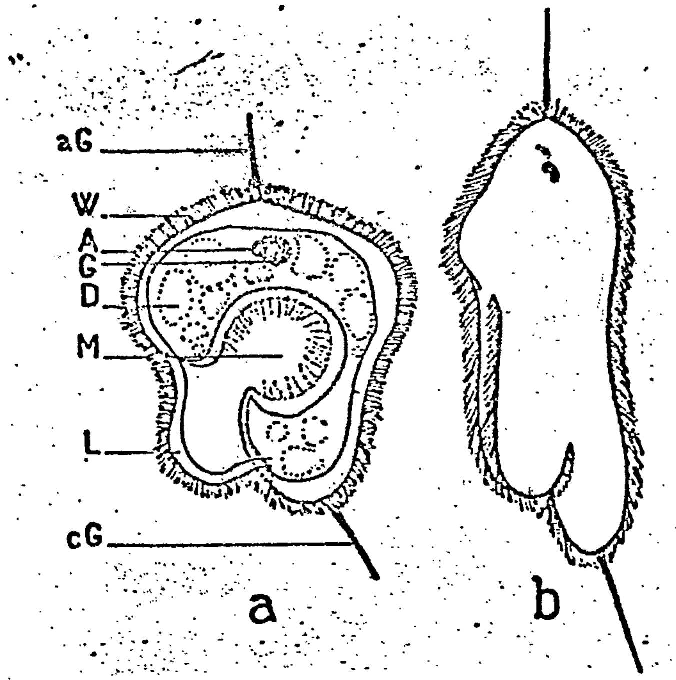



Fig. 3: Gőtte's larva of Stylochus pilidium aged 3 days; a. optical cross-section; b. larva moving under the glass; ag. apical flagellum; cg. caudal flagellum; W. Cilia; A. Eye; G. Ganglion; D. Yolk; M. Stomach; N. Buccal lobes.

The flatworm daily devours 1-3 oysters, according to their size; small flatworms generally attack small oysters or those of equal size to themselves, and big flatworms also devour oysters which are much bigger than they are. In oysters of 5-6 centimetres there are usually 2-3 flatworms, but even up to 6 big flatworms can be found. We do not know if in such cases the oyster is attacked simultaneously by several flatworms or if just one single one penetrates the living oyster and the others follow it into the already open oyster, attracted by the juice of the meat. Often inside the valves two flatworms one on top of the other (coition ?) and eggs also are found (Table I, fig. 2).

The flatworms begin to deposit eggs preferably on smooth surfaces 2-3 days after being placed in the aquarium. In Table I, fig. 2 shows three heaps of eggs deposited inside an oyster devoured a short time ago; fig. 3 a mass deposited a short time ago on the plate glass of an aquarium. The eggs are spread in a thin layer and affixed to it by means of a special substance, which rapidly coagulates, so that it is possible to pull it (the layer) off and it looks like a thin plate. Development at a temperature of 22-23°C lasts for approximately 8 days; the larva 0.12 mm. (Fig. 3A) in length lacks the lobes peculiar to the typical Müller larva and is called after the name of its discoverer "Götte larva". It is characteristic of the polyclad. Its shape varies; usually it is round, but during locomotion it can become elongated, reaching (a length) 3 times its diameter (Fig. 3b). All the body is covered with cilia (W), which are used for movement. At the apical pole there is a long ciliated flagellum (a. G) under which the brain (G) and two black ocular spots (A) are placed. There is another flagellum at the opposite pole (cG). Of the 8 preexisting lobes there remain only 2 immediately afterwards (L) and they are placed laterally to the esophagus.

The larvae have positive phototaxis and always gather together in the part of the aquarium exposed to the light. It was possible to keep them alive for ten days, but then they died through lack of suitable food. The transition to sedentary life should develop after 15-20 days of larval life.

The pronounced phototaxis of the larvae is, however, of great importance, since they propel themselves to the same surface strata, where the oyster larvae are and the twigs suitable for receiving them. The invasion of the young flatworms, therefore, coincides with the setting of the oyster larvae; this biological plunder must be borne in mind in the fight against the flatworm.

Geographical Distribution

The Stylochus pilidium was found in its natural environment only in the Gulf of Naples by Lang (1884), who was the first one to describe it. It is thus new to the Adriatic. In fact, it was not mentioned either by Graeffe (1903), or by Cori, who for decades explored the Gulf of Trieste, and neither by Micoletzky (1910) and Steinböck (1933), who were particularly involved with the Turbellaria of the Adriatic Sea. This species, in view of its remarkable size, could certainly not escape their notice; therefore, it can be allowed that it arrived in the Adriatic only recently.

Plehn (1896) says of the Stylochus pilidium "known up to now for the Mediterranean two specimens were discovered by Chierchia.......at Valparaiso on the deck of the steamship". This was the frigate "Vettor Pisani", which in 1882 was going round the world, and left from an Italian port. It is therefore possible, that they were transported there from the Italian coast.

Transports of polyclads by means of ships have often been observed; Verrill (1895) for example found a specimen of the Stylochus frontalis type on the keel of a steamship which had then returned from Carolina (sic) (*); Plehn (1896) states that she found two typical specimens of her Diplopharyngeata

* Translator's Note: Presumably either from South or North Carolina, U.S.A.

_filiformis_ north of the Northern point of Sumatra, sticking to a floating log. I, also, in summer of 1933, observed in the Rovigno shipyard on the keel of a cutter, which plied the Adriatic Sea, in the midst of thick cluster of Bryozoa, specimens of _Thyzanozoon_ _Brocchi_ and in such great number, that over one-quarter of a square metre it was possible to count from 8-10 adult specimens. They were living together with Caprellae and with other Amphipoda.

There is a certain amount of shipping movement in the Leme Canal; ships coming from Venice and Ravenna, carrying firewood and, for some years, big steamships arriving from Pescara, but also from Germany, Denmark, Norway and other countries, to load the bauxite, which is used in the extraction of aluminium, at Cul di Leme. They cross the Mediterranean and also come into Italian ports to take on fuel. I therefore think it probable, that the flatworm may have been transported by steamships, the more so because it clings to the substrate, it cannot swim (like for example the _Thysanozoon_, which however can also be transported by ships) and it is detached only with difficulty during navigation. In the Leme oyster beds the attack by planarians could have occurred by means of larvae deposited by the flatworms carried by steam ships. The larvae completed their development on the stakes, intended for the collection of oysters.

## The Damage Caused to Oyster Beds

Up to now two flatworms causing damage to oysters have been observed; the _Thysanozoon_ _Brocchi_ Grube which, however, is of small importance. A specimen was nevertheless found in a young semi-devoured oyster but it is so rare (during the summer only 10 specimens were collected), that it cannot, like the Stylochus, cause remarkable damage. However, it is necessary to bear in mind, that under favourable circumstances, and in view of its wide diffusion in the Adriatic, it could produce serious damage to the oyster beds. It is combatted in the same manner as the Stylochus.

But the greatest enemy of the oyster beds is undoubtedly the Stylochus pilidium. This planarian also attacks here and there both young specimens and those up to a size of four centimetres of Mytilus galloprovincialis (mussels, molluses), but it has a special liking for young oysters of a size of up to four centimetres; the oysters aged one year are attacked considerably less, the older ones, at least up to now, not at all. (Table 1, Figure 1). The greatest losses occurred in July 1934 in oysters of a size of 0.8 to 3.5 centimetres; the oldest among them were 10 weeks old. The worst invasion by planarians occurred at the same time and almost all the young oysters were lost. Out of 20 stakes (Table I, Figure 4) removed from two different points in the canal we found that the ratio between dead and living oysters was 702:167 846:57 respectively, thus there were losses of 76.4% and 93.26%. Unfortunately it was not possible to establish the number of flatworms which caused this destruction as the stakes had been removed a few days beforehand. A realistic picture of the serious damage was given to us, however, by the examination of one of the numerous buoys; these were put in place approximately 2½ years ago and after five months inasmuch as the oysters of the year had developed there, that is to say, in October

1934, they were completely re-cleaned. We found there:

| | | Oysters | |
|---|---|---|---|
| | | Dead | Living |
| Oysters of the year | > 8 mm. . . . . . . | 22 | 1 |
| | 8 - 15 " . . . . . . . . | 112 | 2 |
| | 16 - 25 " . . . . . . . . | 104 | 6 |
| | < 25 " . . . . . . . . | 43 | 9 |
| | 1 - 1½ years . . . . . | 15 ↑ (mostly 1 year old) | 29 ↑ (1½ years old) |
| | 2 - 2½ years . . . . . | 3 | 23 |

that is to say, out of 299 oysters of that year 281 of them were destroyed, or rather 94%. 28 flatworms were discovered living on the buoy and more specifically: 1 <u>Thysanozoon</u> and 27 <u>Stylochus</u> of 3 to 5 centimetres in length.

Even though for the entire summer, up to September, mature oysters may be found, which spawn larvae, these however cannot even approximately make up for the losses suffered in the oyster beds.

We show hereunder the record of some experiments made in the aquariums:

Two days before the beginning of the experiments the stakes with oysters of 8 to 12 weeks old were placed for 10 to 12 minutes in fresh water and the dirt and detritus were cleaned off with a brush. Shortly before the experiment the right valve was removed from all the open oysters.

6/VIII - $11^h$: 5 <u>Stylochus pilidium</u> of a length of from 15 to 25 mm. were placed on each of the five stakes and left for a few minutes in a damp place, so as to allow the flatworm to attach itself. Then they were replaced in aquarium A in running seawater. Five stakes without flatworms were placed in aquarium B as a control.

11.30$^{h}$: some flatworms detached themselves from the stakes and withdrew to a corner of the aquarium. They were replaced on the stakes.

Aquarium A

| | Number of oysters eaten | | | Number of flatworms on the stakes |
|---|---|---|---|---|
| | ∠15 mm. | 8 - 15 mm. | >8 mm. | |
| Stake 1 . . . . . | - | 3 | - | 1 |
| " 2 . . . . . | 2 | 6 | 2 | 2 |
| " 3 . . . . . | 2 | - | - | 1 |
| " 4 | - | 1 | 1 | 1 |
| " 5 | - | - | - | - |

All the other flatworms were found on the glass of the aquarium in the darkest corners and had deposited numerous eggs.

Aquarium B

| | Number of opened oysters | | | No. of flatworms |
|---|---|---|---|---|
| | ∠15 mm. | 8 - 15 mm. | >8 mm. | |
| Stake 1 . . . . . | - | - | - | - |
| " 2 . . . . . | - | 1 | - | - |
| " 3 . . . . . | - | - | - | - |
| " 4 | - | - | - | - |
| " 5 | - | - | 1 | - |

Aquarium A

| | No. of oysters eaten | | | No. of flatworms on the stakes |
|---|---|---|---|---|
| | ∠15 mm. | 8 - 15 mm. | >8 mm. | |
| Stake 1 . . . . . | 1 | 6 | 2 | 1 |
| " 2 . . . . . | 2 | 7 | 3 | 2 |
| " 3 | - | 3 | - | 1 |
| " 4 | 2 | 2 | 2 | 1 |
| " 5 | - | - | - | - |

Aquarium B

| | No. of open oysters | | | No. of flatworms |
|---|---|---|---|---|
| | ∠15 mm. | 8 - 15 mm. | >8 mm. | |
| Stake 1 . . . . . | - | 1 | - | - |
| " 2 . . . . . | 1 | - | 1 | - |
| " 3 . . . . . | 1 | - | - | - |
| " 4 . . . . . | - | - | - | - |
| " 5 | - | - | 1 | - |

Aquarium A

| | No. of oysters eaten | | | No. of flatworms on the stakes |
|---|---|---|---|---|
| | ∠15 mm. | 8 - 15 mm. | >8 mm. | |
| Stake 1 . . . . . | 1 | 1 | 3 | - |
| " 2 . . . . . | 1 | 3 | - | - |
| " 3 . . . . . | 2 | 2 | 1 | - |
| " 4 | 2 | 2 | 1 | - |
| " 5 | - | - | - | - |

Aquarium B

| | No. of open oysters | | | No. of flatworms |
|---|---|---|---|---|
| | ∠15 mm. | 8 - 15 mm. | >8 mm. | |
| Stake 1 . . . . . | - | 1 | - | - |
| " 2 . . . . . | 1 | - | 1 | - |
| " 3 | 1 | - | - | - |
| " 4 | - | - | - | - |
| " 5 | - | - | - | - |

On the 11th day no flatworms were found on the stakes; all had abandoned the stakes and were found in the darkest corners of the aquarium. A migration of flatworms on the stake did not take place during the experiment, as is shown by stake 5.

The five flatworms devoured 66 oysters in five days. Removing the empty oysters (as is shown by control aquarium B), which amount to 11, there is an overall loss of 55 oysters due to the flatworm: therefore approximately (a loss of) more than two oysters per day for every flatworm.

Experiment St. P. 17.17.8. A stake with 10 oysters washed and recleaned (Table I, figure 6a).

18/VIII 2 Stylochus are placed on it.

| | No. of oysters eaten | | |
|---|---|---|---|
| | ∠15 mm. | 8 - 18 mm. | >8 mm. |
| 19 - VIII. . . . . . . . . . | 2 | - | - |
| 20 - 21 - VIII . . . . . . | the flatworms abandon the stakes but are replaced | | |
| 23 - VIII . . . . . . . . . | - | - | 1 |
| 24 - VIII . . . . . . . . . | 1 | - | - |
| 25 - VIII . . . . . . . . . | - | 3 | - |
| 26 - VIII . . . . . . . . . | 1 | - | 2 empty stake |

The two flatworms devoured ten oysters in five days. In Table I figure 6b shows the same stake as the figure, but with open valves. In table I, figure 6c the right valves have been removed in order to show the flatworms (P) *in situ.*

We observed later, that in the lattices placed between the surface and one meter in depth there was a greater number of oysters not eaten by the flatworm, than in those placed at a greater depth, a fact due in all probability to the low degree of salinity of the surface water. In October 1934, I found on 20 stakes closer to the surface, removed from two trellises 145 living oysters, that is to say 7.5 per stake and 4 big flatworms which had probably come (emigrated) from the nearby buoys, which bore many of them; on 20 deeper stakes (there were) only 4 living oysters, that is to say 0.2 per stake and no flatworms. The few oysters remaining on one stake, subsequently, developed very rapidly; on the 14th of October they already measured approximately 5 centimetres.

At the end of October it was possible to make a summary appreciation of the damage caused by the flatworm; of the 4,500 lattices with 600,000 stakes placed in May to take the larvae, so many were destroyed that perhaps 1000 healthy lattices remained. Whilst in other years it was possible to count on 15 to 25 oysters of one year per stake, that is to say out of 2,800-4,200 pieces for every lattice, which carries 140 stakes, the product of this year could be estimated at 200-300 oysters for every lattice, that is to say at barely 250,000 oysters of one year. If it is calculated that 1/3 are lost before the oysters are mature enough for sale, in 1936 there were barely 160,000 oysters. During normal years the product amounts to 1,300,000 to 1,700,000 oysters; the loss is therefore 1,140,000 pieces. If the sales price is Lit. 2.50 (20 Canadian cents) per kilogram (1000 oysters = 60 kilograms), the loss for the Leme establishment and therefore for the Italian economy was of at least Lit. 165,600 (Canadian $13,248.00).(*)

MEANS OF COMBATTING THE FLATWORM

In order to fully combat the flatworm it is necessary to bear in mind two facts which concern the system of breeding them.

---

(*) Translator's Note: In 1935 the Italian lire was worth approximately 8 Canadian cents.

1) The oysters hang freely in the water, that is to say they are not in contact with the bottom. Since the _Stylochus_ does not swim freely in the water, the oysters cannot be attacked by the adult animal. The strings, which support the oysters are however, attacked by the flatworm larvae as they move to the bottom, when they cling to all kinds of supports on the water's surface that is to say, to rocks, pieces of wood found along the beach, buoys, strings and oyster stakes.

2) All the oysters of the establishment can be placed in the dry state and disinfected, and this greatly facilitates the battle against the flatworm. Thus there is a remarkable gain, in the fight against the parasites which infest natural oyster beds, where it is almost impossible completely to dredge up, as Danglade (1919) recommends, all the oysters and the empty shells.

In the struggle against the flatworm various experiments were carried out especially with either young oysters or those up to 14 weeks old, these being attacked with great partiality by the parasite.

1) _Experiments with exposure to the dry state._ The stakes with the oysters and the polyclads are exposed for half an hour to the sun and then placed for 24 hours in the shade. The oysters are still alive, the flatworms, on the other hand, at least those placed outside are dried up. It often happens that the flatworms take refuge in the oysters and that these, by closing themselves up, preserve the flatworm from the drying process, as it is in a moist spot which is half full of seawater. The flatworms also take refuge where the stakes are threaded on to the strings and in their loops and can thus live for 24 hours in the dry state. The flatworms die in great numbers, but they are not completely

destroyed. Keeping the young oysters in the dry state for too long a period causes them to suffer.

2) Experiments with fresh water soakings. We obtained complete results from the experiments carried out with fresh water or with very diluted seawater. In fresh water the flatworms die in a little more than a minute (and the larvae even more rapidly), while the oysters close their valves and can resist without damage for a long time; the young oysters resist at a temperature of 19 to 22°C for five to six days, adult Japanese oysters at a temperature of 19 to 20°C for approximately 20 days (according to Yazaki, 1932).

In Table III it is possible to see the results of some research work regarding flatworms, flatworm larvae and young oysters (up to 10 weeks old), placed in water at ever greater saline concentrations (from 0 to 100°/oo) and at a temperature of 18.5 to 22°C. The flatworms as much as the larvae and oysters favour the same degree of salinity between 25°/oo and 55°/oo and stay alive (flatworms and oysters up to 30 days, larvae up to 10 days). The flatworms, as much as the larvae and the oysters are eminently euryhaline. They react, however, in a different way to low and high salinities. The larvae are the most sensitive (table III 0) since their tissue does not put up any resistance to the penetration of the water. The flatworms (table III +) secrete a thick layer of mucuous, which acts as protection and which can therefore preserve them from death for some time. The oysters (table III ▲) can seal their valves hermetically and keep alive for a long time. Death in this case is due to lack of oxygen, which causes a relaxation of the adductor muscles and therefore, the entry of the water.

To combat the flatworm it is sufficient to triple the duration of the soaking at various concentrations, as appears from the experiments; 15 minutes are enough in fresh water in fact it has been shown experimentally that the flatworms which have taken refuge inside the valves die also. Thus, the time is sufficient (shown in shaded portion of table III). The greatest saline concentrations (of $37^{o}/oo$), have, practically, very little importance and can be used in localities close to saline localities and lacking in fresh water.

The fight against the flatworm using fresh water or slightly brackish water is very efficient. In the Leme Canal it is very difficult to procure fresh water in sufficient quantity, since in summer there are no springs which flow into its surface and the Cul di Leme tanks are barely sufficient for local needs. It would be necessary to transport the water from Rovigno by means of barges and that would cost too much. It is possible therefore, on the other hand, to utilize successfully the water of the Pia Ferra spring situated approximately half-way up the canal under an ancient stone quarry. The spring at certain times gushes fresh water but usually it is also brackish during low tide. On 23rd VIII 1934 the salinity at low tide was $4.47^{o}/oo$, at high tide $27^{o}/oo$. In order to combat the flatworm water of $15^{o}/oo$ salinity is sufficient, but in this case the duration of the soaking is much longer. It would be advisable to divert this spring and construct a basin in such a way as to prevent filtrations of (brackish) water during high tide.

Up to now the lattices were washed in tanks full of fresh water or brackish water and then hung from tables. The result of this treatment was satisfactory. Whilst before the soaking two to six flatworms were found on every stake, 14 days after the soaking barely one was found out of 20 to 25 stakes. A second soaking completely destroyed the flatworms. One single soaking is not sufficient to destroy the flatworms for ever, since during the summer a reinfection occurs on account of the larvae. Centers of infection are:

1) Adult oysters welded to the cement cylinders; here and there on the strings flatworms were found, which live on the young oysters which have developed on oysters of 1½ - 2½ years. The big oysters are not devoured.

2) Wooden poles, buoys, lifebuoys, steel cables used in oyster beds. Young oysters develop on them and offer nutrition to the flatworm. On 3rd October, 1934, for example, on a big lifebuoy bearing oysters of 1-2 years old, there were found in a recently eaten 5 cm. oyster 3 <u>Stylochus pilidium</u> 30, 28 and 15 mm. long, respectively, which immediately deposited eggs in the aquarium (See also page 15).

3) Wood, branches and tree trunks, etc. which are found along the beach up to a depth of 8 cm. serve as an attachment for the oyster larvae and offer nutrition to the flatworms.

On the basis of the observations made up to now to combat the flatworm, recommendations for proceeding in the following manner are made:

A) <u>Before proceeding with new cultures remove all the oysters which are not found on the stakes, that is to say</u>:

1) Clean, during the first days of May, all the stakes, lifebuoys, buoys and steel cables in the oyster beds;

2) Dredge up along the beach all pieces of wood, branches, etc.;

close to the firewood loading points, and near the oyster beds the branches with oysters should be completely removed. For shallow depths up to 4 m. it is possible to use pincers.

B) When replacing the stakes on new strings and cementing the oysters aged 1 year, remove all the young oysters.

C) Washing of the oyster strings:

1) the stakes with the young oysters are washed during the first year every 4 weeks commencing from June;

2) during the first year wash all the oysters of 1-3 yrs. in June, August and September. It is necessary to take care quickly to wash the strings one after the other to prevent an infection by means of strings which have not yet been washed.

From the results obtained during the year it is possible to know if even subsequently the soakings must be continued to the same extent. Let us remember, furthermore, that in the cases observed up to now (Staed, Danglade) the flatworms disappeared as rapidly as they came, and then reappeared sporadically en masse after several years. It is not yet known upon what this fact depends. As we do not know if in 1934 at Leme the development of the flatworms reached its zenith, it is better to combat them and to take preventive measures immediately, rather than lose yet once again all the young oysters of the year. With these methods it is impossible completely to destroy the flatworm, since it always finds favourable living conditions along the coast, but because of a lack of suitable nutrition there will never be a strong increase (in their number) and this will therefore prevent mass infection by the larvae.

## German Bibliographic Items

4. Oyster cultivation in Norway.

6. List of the fauna of the Gulf of Trieste.

7. The Polycladida (marine planarians; flatworms) of the Gulf of Naples and the neighboring sea areas. Fauna and flora of the Gulf of Naples, Monograph No. 11, 1884.

9. The turbellarian fauna of the Gulf of Trieste.

11. New Polycladida collected by Captain Chierchia during the voyage around the globe of the corvette Vettor Pisani; by Professor W. Kueckenthal in the northern polar sea; and by Professor O. Semon in Java.

13. The turbellarian forms from the area around Rovigno.

## Italian Bibliographic Items

8. Notes on the biology of the oyster (*Ostrea edulis* L.): I. Birth of the larvae and duration of the larval period.

14. Observations on the thermohaline regime of the Adriatic near Rovigno in 1930-1931.

## German Summary

During the summer of 1934 the polyclad *Stylochus pilidium* Lang appeared in great numbers as pest attacking oysters grown commercially on beds in the Canal di Leme near Rovigno d'Istria. These flatworms preferentially infested the oyster brood hatched that year, with individual oysters measuring 8.35 mm in diameter. One-year-old oysters were attacked to a lesser extent, and oysters several years old almost not at all. The loss among the newly hatched oysters amounted to approximately 87 per cent, corresponding to a commercial loss in marketable oysters in 1936 of about 165,000 liras or Canadian $13,200 (in 1935).

On the basis of the breeding methods used in oyster growing and the life history of this marine flatworm, the following control measures are recommended, which, in part, have already been employed in the field, where they produced satisfactory results:

(A) All oysters of the breeding colony not attached to the wooden breeding blocks must be removed, i.e.

(1) All timber piles, floating buoys, and steel cables on the oyster breeding grounds must be scraped clean before the start of the new spawning period (early in May); and

(2) The shore and the sea bottom down to a depth of about eight meters must be dredged in order to remove from the water all pieces of wood, branches, and other waste material, and this, in particular, in the proximity of sites where timber is loaded for transportation.

(B) All young oyster brood must be removed from the ropes when breeding stocks with adult oysters are re-introduced.

(C) The ropes together with the adhering oysters must be soaked in either fresh water or slightly brackish water (with saline contents up to 15 per cent); the soaking times employed must correspond to the data presented in Table 3 (hatched spaces), viz.

(1) The ropes with oyster brood at intervals of four weeks during the first year starting in June; and

(2) The ropes with oysters one year old or several years old once during June, once during August, and once during September.

German Summary (continued)

While carrying out this procedure, care should be taken to ensure that the entire oyster material of the breeding colony is subjected to soaking in succession as rapidly as possible in order to prevent re-infection.

BIBLIOGRAFIA

BIBLIOGRAPHY.


1. Amemija I., *Notes on experiments on the early developmental stages of the Portuguese, American and English native oysters, wich special reference to the effec of varying salinity.* Journ. mar. biol. Assoc., Vol, 14, pp. 161-175, 1926.

2. Bock S., *Papers from Dr. Th. Mortensen's Pacific Expedition* 1914-16. XXVII Planarians Part IV. New Stylochids. Vidensk. Medd. fra Dansk naturh Foren. Bd. 79, pp. 97-184, 1925.

3. Danglade E., *The flatworm as an enemy of Florida oysters. Bureau of Fisheries Report* 1918. Appendix V, Document N. 869, pp. 1-8.

4. Gaarder T., *Austernzucht in Norwegen.* Intern. Revue Hydrobiol. Bd. 28, pp. 250-261, 1933.

5. Galtsoff P. S., *Experimental study of the function of the oyster gills and its bearing on the problems of oyster culture and sanitary control of the oyster industry.* Bull. Bureau Fisheries, Vol. XLIV, Document N. 1035, pp. 1-39, 1928.

6. Graeffe E., *Übersicht der Fauna des Golfes von Triest X. Vermes.* Arb. Zool. Inst Wien und Zool. Station Triest, Bd. 15, pp. 317-332, 1905.

7. Lang A., *Die Polycladen (Seeplanarien) des Golfes von Neapel und der angrenzenden Meeresabschnitte. Fauna und Flora des Golfes von Neapel,* XI. Monographie 1884.

8. Mazzarelli G., *Note sulla biologia dell'Ostrica (Ostrea edulis L.): I. Nascita dell larve e durata del periodo larvale,* Boll. Società dei Naturalisti di Napoli Ser. II, Vol. XIV, 1923, pp. 151-159.

9. Micoletzky H., *Die Turbellarienfauna des Golfes von Triest.* Arb. Zool. Inst. Wien und Zool. Station Triest. Bd. 18, pp. 167-182, 1910.

10. Palombi A., Stylochus inimicus *sp. nov. Policlado acotileo commensale di* Ostrea virginica *Gmelin delle Coste della Florida.* Boll. di Zoologia, Vol. II, pp. 218-225, 1931.

11. Plehn M., *Neue Polycladen gesammelt von Herrn Kapitän Chierchia bei der Erdumschiffung der Korvette Vettor Pisani, von Herrn Prof. W. Kückenthal im nördlichen Eismeer und von Herrn Prof. O. Semon in Java.* Jen. Zeitschr. Naturw. Bd. 30, pp. 137-174, 1896.

12. Stead D. G., *Preliminary Note on the Wafer* (Leptoplana australis), *a species of Dendrocoelous Turbellarian Worm, Destructive to Oysters.* Departm. of Fisheries, New South Wales November 1907, pp. 1-6.

13. Steinböck O., *Die Turbellarienfauna der Umgebung von Rovigno.* Thalassia, Vol. I, N. 5, pp. 1-33, 1933.

14. Vatova A., *Osservazioni sul Regime termoalino dell'Adriatico presso Rovigno nel* 1930-31. Note dell'Istituto Italo-Germanico di Biologia marina di Rovigno d'Istria. N. 9, pp. 1-33, 1933.

15. Verrill A. E., *Marine Planarians of New England* Trans. Connecticut Acad., Vol. VIII, pp. 459-519, 1893.

16. Yazaki M., *On the Osmoregulation of the blood of several marine and fresh water mollusces. I. The Japanese oyster,* Ostrea circumscripta *Pils.* Science Reports, Ser. IV, Vol. VII, pp. 229-238, 1932.

# EXPLANATION OF THE TABLES

Table I.

Fig. 1 - Live oyster aged 2½ yrs. with 1 yr. old oysters (a) and 3 young oysters already devoured (b-d). Enlarged 0.8 X.

Fig. 2 - Young 2 cm. oyster with eggs of Stylochus, enlarged 3.5 X.

Fig. 3 - Eggs of Stylochus on the walls of an aquarium, enlarged.

Fig. 4 - Piece of string with stakes (lattice).

Fig. 5 - Stake with devoured oysters; enlarged 0.6 X.

Fig. 6 - Stake with 10 oysters aged 10 weeks, enlarged 0.8 X.

a) Before the attack of 2 flatworms, all the oysters are closed;

b) After 5 days: all the oysters are open and eaten;

c) The right valves have been removed; in P the 2 flatworms are seen.

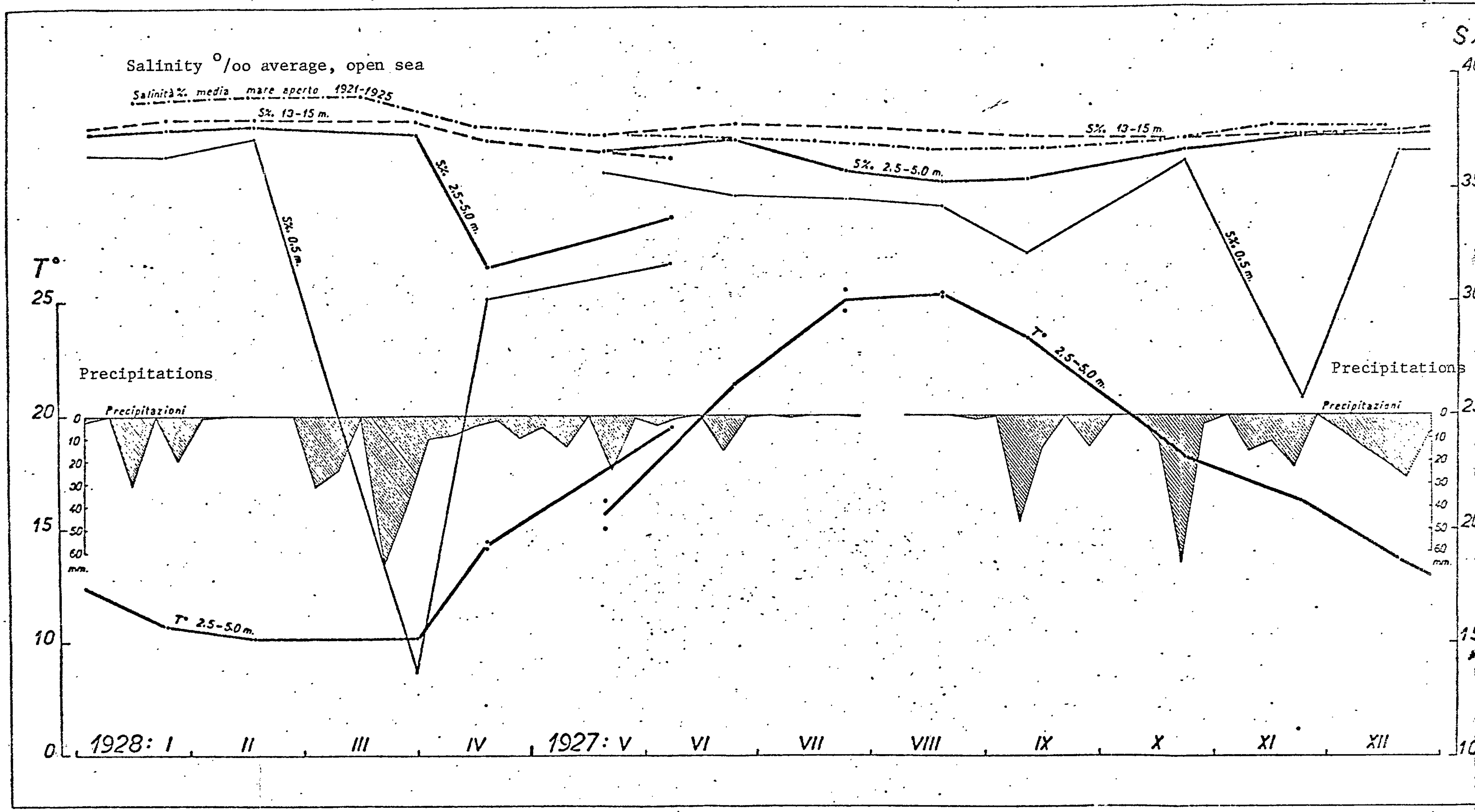
Table II. Graph I.

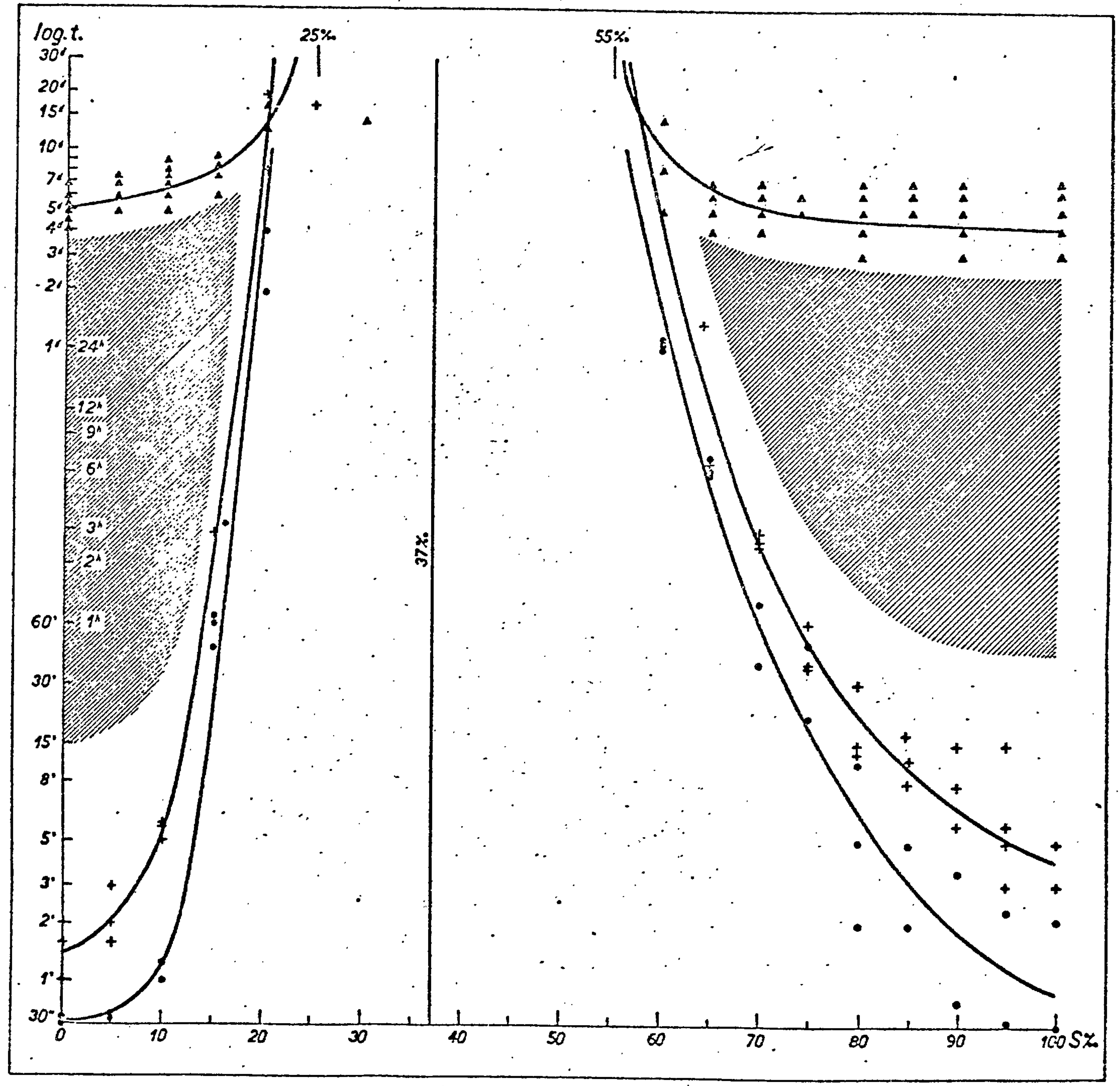
Salinity and temperature in the Leme Canal near the oyster beds. V/1927-VI/1928; temperature in °C, salinity in °/oo at 0.5 metres; 2.5-5, 13-15. Average salinity of 1921-25 at 1 mile off-shore from Rovigno. ..........: average curve of the precipitations at Rovigno from V/1927 - IV/1928.

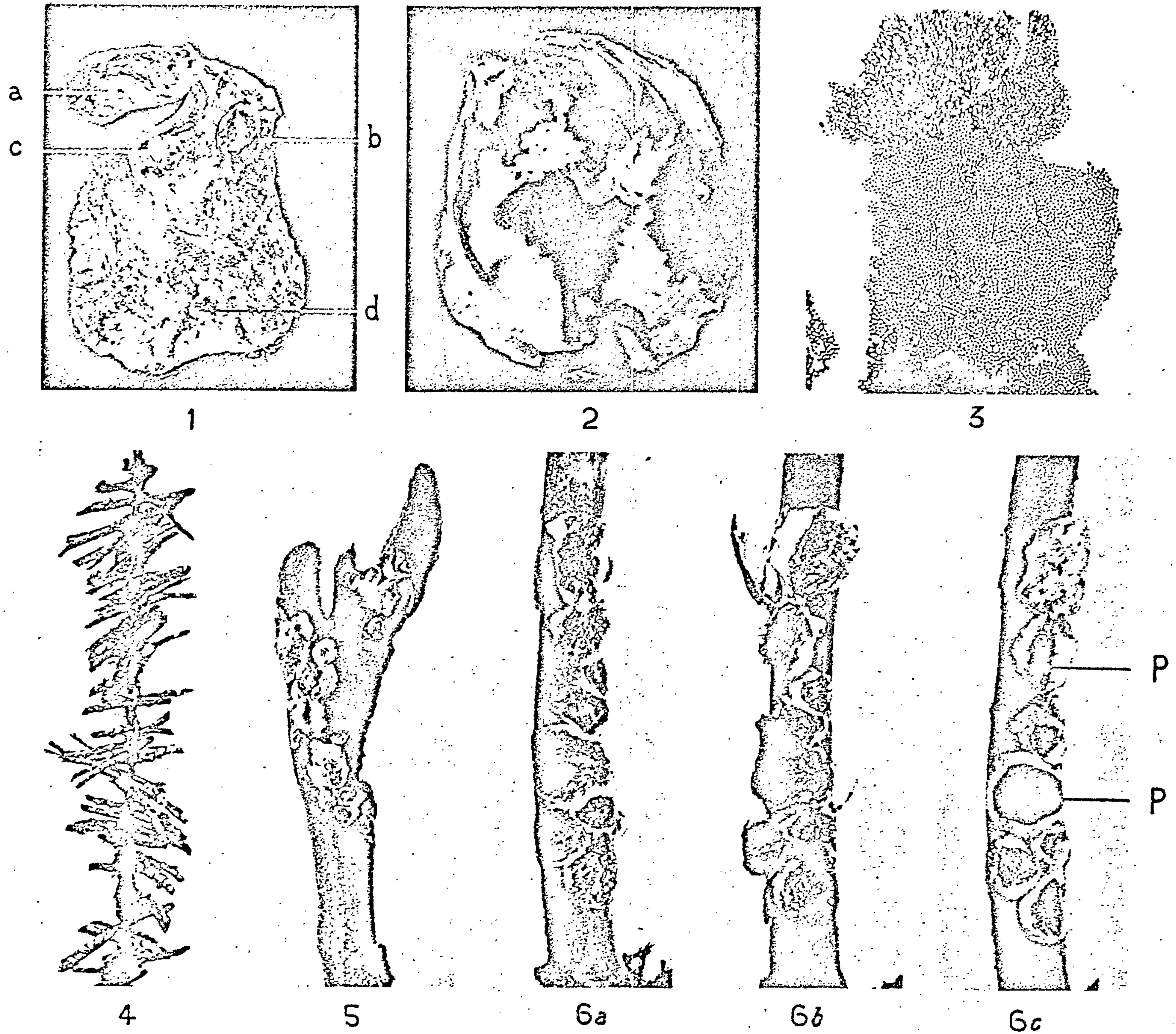
Table III. Graph II.

Sensitivity of the flatworms, larvae and oysters towards increasing saline concentrations; abscissas: salinity per °/oo, log. time ("seconds, 'minutes, h = hours, d = days), + adult specimens of Stylochus pilidium; every + represents a flatworm, 0 Stylochus larvae of 1-2 days; every 0 represents some hundreds of dead larvae; ▲ represents oysters of 6-10 weeks old;

every △ represents 5 dead oysters; the small oysters generally die before the big ones. Salinity of 25-55$^{o}$/oo, at which the flatworms stay alive and the larva develops until the 10th day. The shaded area represents the area available to combat the flatworm at low and high saline concentrations, without causing damage to the oysters.


Salinity °/oo average, open sea
Salinità ‰ media mare aperto 1921-1925
S‰ 13-15 m.
S‰ 2.5-5.0 m.
S‰ 0.5 m.
T°
T° 2.5-5.0 m.
Precipitations
Precipitazioni
mm.
1928: I
II
III
IV
1927: V
VI
VII
VIII
IX
X
XI
XII


log.t.
25%.
55%.
37%.
30′
20′
15′
10′
7′
5′
4′
3′
2′
1′ 24^h
12^h
9^h
6^h
3^h
2^h
1^h
60″
30″
15″
8″
5″
3″
2″
1″
30″
0
10
20
30
40
50
60
70
80
90
100 S%.




e giova-
X.
chiuse;
arie.
XI 1928;
l miglio
igno dal
line cre-
i. h ore,
aria.
di larve
rte; le
7-55 ‰,
giorno.
narie a