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Stylochus mediterraneus (Turbellaria: Polycladida), Predator on the Mussel *Mytilus galloprovincialis*

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Abstract

The polyclad *Stylochus mediterraneus* Galleni has been found associated with the mussel *Mytilus galloprovincialis* Lmk., on which it feeds. Polyclads allowed to feed freely on groups of mussels of different sizes preyed mainly on small mussels <25 mm in length. The predation rate (number of mussels eaten per no. of polyclads per no. of days) ranged between 0.07 and 0.33. The average amount of food ingested by 1 polyclad feeding on mussels 16 to 25 mm or 26 to 35 mm in length was 7.1 and 11.2 (dry weight) mg per day, respectively. Before penetrating the mussels, the worm first straddles the valves at the posterior edge of the shell and then, after having digested the posterior adductor muscle, removes and swallows the soft parts of the prey.

Introduction

Predation of polyclads on other marine animals is well documented. Contributions clarifying their nutritional preferences have been published by Jennings (1957, 1968, 1971, 1974a, b), who investigated ingestion and the physiology of digestion in some polyclad species; and by Koopowitz (1970) and Koopowitz *et al.*, (1976), who studied the role of the brain and other nervous structures during predatory behaviour in *Planocera gilchristi* and *Notoplana acticola*. However, most authors have studied more specifically the relationships between polyclads and those animals which, under natural conditions, constitute their prey.

Polyclads may actively prey upon species belonging to different animal groups. Their diet may be monospecific or involve two or more species. Table 1 summarizes our present knowledge on the subject. The literature is mainly devoted to predation on molluscs, with regard to the serious damage effected by these worms on edible mollusc cultivations (see Cheng, 1967). For instance, Kato (1944) surveying Japanese polyclads, refers to at least 5 species which are predators on clams or snails; 3 of these may effect serious damage on the edible mollusc cultivations of Japan. The oyster farms of the Atlantic and Pacific coasts of North America have also experienced heavy losses caused by polyclads (see Christensen, 1973). Damage can be so serious that, in France, severe controls are carried out on imported oysters from Japan to prevent the accidental introduction of possible predators (Gruet *et al.*, 1976). Infestation by imported worms has actually occurred in the oyster farms on the west coast of the USA (Woelke, 1956).

In the Mediterranean Sea, Cerruti (1926, 1932, 1941) reports *Discocelis tigrina* as a possible predator of oysters. Bytinski-Salz (1935) refers to the serious losses (up to 90% of the youngest oysters) in the oyster beds of Rovinji (Yugoslavia) caused by a flatworm referred to by him as *Stylochus pilidium*, but whose actual name is *Stylochus mediterraneus*. Bytinski-Salz also reports occasional predation by this flatworm on young *Mytilus galloprovincialis* (1935, pp 9 and 13).

No further data are available on predation by polyclads on any other species of mussels, except for *Cryptophallus magnus* (Coe, 1946; MacGinitie and MacGinitie, 1949) (see Table 1). Indeed, even in the latest paper on mussel ecology (Seed, 1976) and in the latest contribution to mussel farming (Korringa, 1976), polyclads are never quoted as mussel predators.

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Table 1. Polyclads and their preys, as reported in the literature

Polyclad species	Prey	Source
Family Discocelidae		
Discocelis tigrina Lang	*Ostrea edulis*	Cerruti (1926, 1932, 1941)
Family Taenioplanidae		
Taenioplana teredini Hyman	*Teredo* sp.	Hyman (1944)
Family Stylochidae		
Stylochus californicus Hyman (= *Cryptophallus magnus sensu* MacGinitie and MacGinitie)	Clams and mussels	Coe (1946), MacGinitie and MacGinitie (1949)
Stylochus alexandrinus Steinböck	Barnacles	Present paper
	Oysters and barnacles	Pearse and Wharton (1938)
	Crassostrea virginica	Loosanoff (1956)
	Oysters	Provenzano (1959)
Stylochus ellipticus (Girard)	Oysters	Webster and Medford (1959)
(= *Eustylochus meridianalis*)	*Balanus eburneus*	Arvy and Nigrelli (1969)
	Crassostrea virginica	Landers and Rhodes (1970)
	Barnacles and other bivalves	Landers and Rhodes (1970)
	Balanus improvisus	Branscomb (1976)
Stylochus ferox nomen nudum	Oysters	Bock (1925b)
	Oysters	Danglade (1919)
	Crassostrea virginica	Palombi (1931)
Stylochus frontalis Verrill	*Crassostrea virginica*	Palombi (1936)
(= *S. inimicus* = *S. tenax*)	Oysters, barnacles	Pearse and Wharton (1938)
	Crepidula sp.	Pearse and Wharton (1938)
Stylochus hamanensis Kato	Oysters	Kato (1944)
Stylochus ijimai Yeri and Kaburaki	Oysters	Kato (1944), Yang (1974)
Stylochus mediterraneus Galleni	*Ostrea edulis* rarely *Mytilus galloprovincialis*	Bytinski-Salz (1935)
(= *Stylochus pilidium sensu* Bytinski-Salz)	*Mytilus galloprovincialis*	Galleni *et al.* (1976) and present paper
Stylochus neapolitanus (Delle Chiaje)	*Balanus* sp.	Lang (1884)
Stylochus pilidium (Goette)	*Ostrea edulis*	Cerruti (1941)
Stylochus tripartitus Hyman	*Balanus pacificus*	Hurley (1975, 1976)
Stylochus uniporus Kato	*Paphia (Tapes) philippinarum*	Kato (1944)
Stylochus zanzibaricus Laidlaw	*Balanus amphitrite*, *B. trigonius*, *Elminius modestus*	Skerman (1960)
Stylochus zebra Verrill	*Crepidula plana*, *C. fornificata*	Lytwin and McDermott (1976)
Stylochus spp.	Oysters	Rho (1976b)
Family Cryptocelidae		
Cryptocelis amakusaensis Kato	*Umbonium moniliferum*	Kato (1944)
Family Leptoplanidae		
Freemania litoricola (Heath and McGregor)	Barnacles and nemerteans	Smith (1955)
Leptoplana tremellaris (O.F. Müller)	Polychaetes, isopods, amphipods	Jennings (1957)
?*Leptoplana tremellaris*	Oyster veliger	Cerruti (1941)
	Rostanga pulchra or	Boone (1929)
Notoplana acticola (Boone)	*Aldisa sanguinea*	
	Artemia salina	Koopowitz *et al.* (1976)
Notoplana alcinoi (O. Schmidt)	Amphipods	Present paper
Notoplana australis (Schmarda)	Oysters	Stead (1907)
Notoplana chierchiai (Plehn)	Isopods	Marcus (1954)
Notoplana inquieta (Heath and McGregor)	*Balanus pacificus*	Hurley (1975)
Notoplana saxicola (Heath and McGregor)	Mollusks, crustaceans, rhabdocoels	Heath and McGregor (1912)
Stylochoplana aberrans Kato	Oysters	Kato (1944)
Stylochoplana agilis Lang	Gastropods	Levetzow (1943)
Stylochoplana floridana Pearse	Copepods, annelids	Pearse and Wharton (1938)
Zygantroplana henriettae Correa	Polychaetes, brittle-stars, crustaceans	Correa (1949)
Family Planoceridae		
Alloioplana californica (Heath and McGregor)	Small animals, diatoms	Heath and McGregor (1912)
Planocera gilchristi Jacubowa	*Oxystela* sp.	Koopowitz (1970)
Planocera pellucida (Mertens)	*Velella* sp.	Bock (1925a)
Family Callioplanidae		
Pseudostylochus obscurus (Stimpson)	Oysters	Yang (1974)
	Ostrea lurida, *O. gigas*,	Woelke (1954, 1956, 1959)
Pseudostylochus ostreophagus Hyman	*Crassostrea virginica*	Smith (1955)
	Nemerteans	Smith (1955)
Pseudostylochus sp.	Oysters	Rho (1976b)
Family Pseudoceridae		
Pseudoceros sp.	Oysters	Villadovil and Villaluz (1938)
Pseudoceros crozieri Hyman	Ascidians	Crozier (1917)
Pseudoceros superbus	*Ostrea rizophorae*	Mattox (1949)
	Ascidians, *Didemnum candidum*,	Pearse and Wharton (1938)
Thysanozoon brocchii (Risso)	*Ciona* sp.	Levetzow (1943)
Family Euryleptidae		
Cycloporus papillosus Lang	Synascidians	Bock (1925a)
	Ascidians	Jennings (1957)
Eurylepta leoparda Freeman	Ascidians	Lambert (1968), Lei Ching (1977)
Family Prosthiostomidae		
Prosthiostomum montiporae Poulter	*Montipora* sp.	Jokiel and Townsley (1974), Poulter (1975)

During research still in progress on taxonomy, kariology and distribution of polyclads on the Tuscan coasts by one of the authors (Galleni, 1976), 3 species of polyclads were found in the beds of *Mytilus galloprovincialis*: *Stylochus mediterraneus*, *S. alexandrinus* and *Notoplana alcinoi*. *S. mediterraneus* is an active mussel predator.

The present paper seeks to contribute to our knowledge on mussel predators and to extend and examine closely, in *Stylochus mediterraneus*, the prey-predator relationship.

Materials and Methods

Observations were made on the biocoenosis characterized by the presence of *Mytilus galloprovincialis* Lmk. along the coasts of Leghorn (Livorno, Italy) between Torre del Marzocco, north of the harbour of Leghorn, and Calignaia, south of the town.

Four sampling localities were selected to test different ecological situations:

(1) Mussel beds facing the open sea, located on wharfs or breakwaters of the harbour which are built of large calcareous blocks; the morphology of the mussel beds depends on the substratum: when this is sufficiently smooth and flat the mussel beds usually tend to cover it completely.

(2) Mussel beds facing the inner waters of the Leghorn harbour or those of the little harbour of San Jacopo, and which are subjected to varying levels of pollution (Cognetti, 1970); the internal sides of the wharfs or breakwaters are of concrete and, because of the flat substratum thus provided, the mussel beds are large.

(3) Mussel beds located on the rocky shore of the town facing the open sea, but suffering a high level of urban pollution; here the coast slopes gently, and is richly covered with mussels.

(4) Mussel beds situated on the coast far from the town (Calafuria and Calignaia); here the coast is steep and organic pollution is not high.

Each station was sampled about every two months.

Samples were collected at or just below sea level. Care was taken in detaching portions of mussel beds from the substrate so that no worm escaped. The wet weight of each sample ranged between 2 and 3 kg. No attempt was made to collect quantitative data about the number of polyclads per kg of mussels or about surface unity. (Under optimal conditions polyclads may be numerous: in a single sample collected on the 8th October 1976 on the side of the main breakwater facing the open sea, we counted 47 specimens of *Stylochus mediterraneus* Galleni and 50 specimens of *Notoplana alcinoi*.)

The samples were then transferred to the Interuniversity Center of Marine Biology at Leghorn, where observations and tests were effected. In the laboratory, mussels were examined and the presence and number of the various species of polyclads were noted. Mussels and specimens of *Stylochus mediterraneus* were then maintained together in a common tank with running sea water at room temperature (15° to 22°C, according to season) for at least 2 to 3 days to acclimatize them to the experimental conditions. Specimens of other polyclad species were identified, counted and fixed.

During the predation tests the mussels and the worms (usually >2 cm long) were put together in glass containers 145 or 185 mm in diameter and 79 or 100 mm high, respectively. The controls contained mussels alone. The containers were covered with gauze and submerged in tanks flushed with running sea water. Each test was usually continued for about 3 to 4 days, rarely longer.

The first group of experiments was carried out on a group of polyclads which had been collected in September 1975 and which were used for more than one test. After each single test they were put together in the common tank for a new acclimatization period.

During the second group of experiments worms were tested only once; when different methods were adopted, they are referred to in the text.

We never used starved worms; before each test the polyclads were allowed to feed freely on mussels in the acclimatization tank.

At the end of each test, in every container we: (1) counted mussel shells which were completely empty, i.e., mussels presumably eaten by the polyclads; (2) counted mussels which had died from natural causes, recognizable by the presence of soft parts still attached to the inner shell surfaces; (3) noted the presence of any worm inside each empty shell and whether any egg had been laid on the shell valves.

The predation rate for each test was calculated as the number of mussels eaten by each polyclad each day, i.e., no. of mussels eaten per no. of polyclads per no. of days.

Results

Ecology of Stylochus mediterraneus

The 3 species of polyclads found in the mussel beds of the harbour and on the rocky shores near Leghorn were not evenly distributed. Only *Notoplana alcinoi* was present at every station; the other two species displayed a narrower distribution. In the studied localities, *Stylochus mediterraneus* lives mainly in the mussel beds facing the open sea and is less numerous inside the harbour. On the other hand, *S. alexandrinus* has been found only in the harbour; it feeds on barnacles, which are abundant in this habitat.

Stylochus mediterraneus was found together with *Notoplana alcinoi* mainly in the biocoenosis characterized by *Mytilus galloprovincialis,* associated with *Corallina* sp. and *Ulva* sp. Such a biocoenosis characterizes medium-polluted waters (Bellan-Santini, 1969). However this author found in such an association, on the coasts near Marseille (France), a different species of polyclad, *Leptoplana tremellaris.* A second species, *S. neapolitanus* has also been found by Bellan-Santini in the biocoenosis of non-polluted waters with strong water movements, characterized by *M. galloprovincialis* or *Cystoseira stricta.*

Stylochus mediterraneus was present throughout the year in the mussel beds on the Leghorn coast. In the winter months, individuals of *S. mediterraneus* of two different sizes were noted: worms <1 cm and worms >3 cm in length. The life cycle of this species may therefore be longer than 1 year. In *Pseudostylochus ostreophagus,* Woelke (1956) recorded a one-year life cycle, which was so pronounced that both in nature and in captivity all individuals died in the summer months, whilst at other times of year representatives of all size groups were present. However, adult *S. mediterraneus* collected in August 1976 were still alive in June 1977 in a laboratory tank maintained at a temperature of 18°C. These worms stopped laying eggs in December, and began again at the end of February. Nevertheless, worms are rare in the winter and spring months, being abundant from June to October.

In nature, quite common are empty mussel shells containing *Stylochus mediterraneus* and with the inner and sometimes the outer surface covered by one or more egg-plates. From these eggs and from others laid in the laboratory and maintained at room temperature, we observed that Götte larvae, characterizing some species of the genus *Stylochus* (Kato, 1940; Rho, 1976a), hatched after about 8 to 10 days. In July 1975, we also collected free-swimming larvae near the mussel beds.

Predation Tests

The presence, in nature, of empty mussel shells often occupied by *Stylochus mediterraneus* or covered on their inner surface with polyclad eggs, is not of course sufficient evidence of an actual predation of these flatworms on mussels. However, laboratory observations show that mussels opened and completely empty, often occurred in containers where mussels and polyclads had been kept together. The polyclads often had fragments of mussels in their intestine, and it was also possible to extract bits of mussel from their pharynx. Moreover, if disturbed the worms may eject fragments of mussels. In experimental and control basins those mussels which died of natural causes were recognizable by the fleshy parts still adhering to the shell.

Experiments were carried out in autumn 1975 using mussels varying in length between 26 and 35 mm. (Containers 1 to 12: Test 1). Results are presented in Table 2.

On the 26th September (Experiment No. 1) 100 mussels were put in each of three containers. Container No. 1 was the control, while 5 polyclads each were put into Containers 2 and 3. The polyclads had been previously maintained for 48 h in the acclimatization tank. The 3 containers were checked after about 72 h (29th September), and empty or dead mussels were replaced. Containers 1 and 2 were checked again after 96 h (3rd October). (Container No. 3 was used for tests unconnected with the present study, and is therefore not included in Table 2.)

Experiment 2 was run simultaneously; the same numbers of mussels (100 per container) were put in Containers no. 4, 5, 6. Container 4 was the control. The numbers of polyclads in the experimental containers (Nos. 5 and 6; 10 polyclads each) were twice those in Experiment 1. Acclimatization period and experiment duration were the same as for containers 1, 2 and 3.

The final experiment of Test 1 (Experiment 3) was begun on 17th October. Mussels and flatworms from Experiments 1 and 2 were used again after a 2-week interval in the acclimatization tank. Eight polyclads each were put into Containers Nos. 8, 9, 11, 12, while Containers Nos. 7 and 10 with mussels alone were used as controls. All containers were checked after 8 days.

Table 2 shows that: (1) *Stylochus mediterraneus* is a predator on mussels: out of 1100 mussels in the experimental containers, 48 shells were empty, a natural death being indicated in only 2 cases;

Table 2. *Stylochus mediterraneus*. Predation upon *Mytilus galloprovincialis* 26 to 35 mm in length (Test 1). Dates on which experiments began are shown. C = control, and E = experimental containers. Duration of each test is shown in days in parentheses. Predation rate = number of mussels eaten per polyclad per day. Containers Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9 were 185 x 100 mm in dimension; Containers Nos. 10, 11, 12 were 145 x 79 mm

Date (1975)	Container No.	Mussels *n*	Polyclads *n*	No. of mussels eaten per container	Total no. of mussels eaten per test	No. of mussels died naturally	Predation rate
Experiment 1							
26 Sept. (3 days)							
C	1	100	0	–	–	1	
E	2	100	5	2	5	0	0.17
E	3	100	5	3		0	
29 Sept. (4 days)							
C	1	100	0	–	–	0	0.15
E	2	100	5	3	3	0	
Experiment 2							
26 Sept. (3 days)							
C	4	100	0	–	–	0	
E	5	100	10	6	9	0	0.15
E	6	100	10	3		0	
29 Sept. (4 days)							
C	4	100	0	–	–	0	
E	5	100	10	5	9	0	0.11
E	6	100	10	4		0	
Experiment 3							
17 Oct. (8 days)							
C	7	100	0	–	–	1	
E	8	100	8	5	11	0	0.09
E	9	100	8	6		1	
17 Oct. (8 days)							
C	10	100	0	–	–	0	
E	11	100	8	6	9	1	0.07
E	12	100	8	3		0	
Total							
C		600	0	–	–	2	
E		1100	87		46	2	Mean 0.12

in the control containers 2 out of 600 mussels died. (2) The daily predation rate varied from 0.07 to 0.17 mussels eaten per polyclad per day. (3) Neither test-duration (3,4 or 8 days) nor the number of worms used (5, 8 or 10) seemed to influence predation rate.

In Experiments 1 and 2 of Test 1 all containers were of the same dimensions (185 x 100 mm), whereas in Experiment 3 containers of two different dimensions were used to determine if mussel density could influence predation rate in any way: the dimensions of Containers Nos. 7, 8, 9 were 185 x 100 mm, while those of Containers Nos. 10, 11, 12 were 145 x 79 mm. No effect was evident: the predation rate in the larger containers was 0.09 mussels per polyclad per day, in the smaller ones it was 0.07.

To examine the effect of container dimension more closely, a second group of experiments using mussels varying in length between 16 and 25 mm (Containers Nos. 13 to 32) was carried out in summer 1976 (Tables 3 and 4). Containers 13 to 20 were 79 mm high x 145 mm in diameter (Test 2; Table 3), while Containers 21 to 32 were 100 x 185 mm (Test 3; Table 4). Although the predation rate varied between 0.07 and 0.33 mussel per polyclad per day, its average, in smaller containers was 0.19, slightly greater than the average for the larger containers (0.17). The slight increase in predation rate observed in Tests 2 and 3 compared to Test 1 (Table 2) was probably due to the smaller amount of food the polyclads obtained from the smaller mussels used in Tests 2 and 3.

The third group of experiments (summer 1976; Containers 33 and 34: Test 4) was carried out in order to test the feeding behaviour of polyclads when allowed to prey on mussels of different dimensions (Table 5).

Two hundred mussels and 20 polyclads were put into each container; mussel dimensions were as follows: 50 mussels <15 mm, 50 between 16 and 25 mm, 50 between 26 and 35 mm, and 50 between 36 to 45 mm. The experiments lasted 8 days.

The results in Table 6 show that 89.4% of the mussels eaten belong to the first two size-classes, with a preferential predation for the smallest individuals (<15 mm, 49.4%). Predation on larger specimens is rare or non-existent. In both experiments, most (64.3%) egg depositions were found on mussels in the 16 to 25 mm size-class.

Table 3. *Stylochus mediterraneus*. Predation upon *Mytilus galloprovincialis* 16 to 25 mm in length. Dimensions of experimental containers = 79 x 145 mm (Test 2). Number of mussel shells with eggs deposited by polyclad on inner surface are also shown. Other details as in Table 2

Date (1976)	Container No.	Mussels *n*	Polyclads *n*	No. of mussels eaten per container	No. of mussels died naturally	Mussel shells with eggs	Predation rate
6 Aug. (4 days)							
C	13	100	0	–	0	–	
E	14	100	5	4	0	1	0.20
28 Aug. (3 days)							
C	15	100	0	–	0	–	
E	16	100	5	1	0	1	0.07
31 Aug. (3 days)							
C	17	100	0	–	1	–	
E	18	100	5	5	0	1	0.33
3 Sept. (4 days)							
C	19	100	0	–	0	–	
E	20	100	5	3	0	1	0.15
Total							
C		400	0	–	1	–	
E		400	20	13	0	4	Mean 0.19

Table 4. *Stylochus mediterraneus*. Predation upon *Mytilus galloprovincialis* 16 to 25 mm in length. Dimensions of experimental containers = 100 x 185 mm (Test 3). Other details as in Table 3

Date (1976)	Container No.	Mussels *n*	Polyclads *n*	No. of mussels eaten per container	No. of mussels died naturally	Mussel shells with eggs	Predation rate
25 June (4 days)							
C	21	100	–	–	2	–	
E	22	100	5	3	1	0	0.15
2 July (4 days)							
C	23	100	–	–	1	–	
E	24	100	5	3	0	0	0.15
6 Aug. (4 days)							
C	25	100	–	–	0	–	
E	26	100	5	0	0	0	0.00
28 Aug. (3 days)							
C	27	100	–	–	0	–	
E	28	100	5	3	0	2	0.20
31 Aug. (3 days)							
C	29	100	–	–	1	–	
E	30	100	5	5	0	3	0.33
3 Sept. (4 days)							
C	31	100	–	–	0	–	
E	32	100	5	4	0	0	0.20
Total							
C		600	–	–	4	–	
E		600	30	18	1	5	Mean 0.17

Table 5. *Stylochus mediterraneus*. Predation upon *Mytilus galloprovincialis* of different size-classes (Test 4). Other details as in Table 3

Date (1976)	Container No.	Mussel size-class (mm)	Mussels *n*	Polyclads *n*	No. of mussels eaten per container	No. of mussels died naturally	Mussel shells with eggs	Predation rate
13 July (8 days)	33	<15	50	20	26	0	3	0.16
		16–25	50		20	0	12	0.12
		26–35	50		5	0	2	0.03
		36–45	50		0	0	0	0.00
Total			200	20	51	0	17	0.31
26 July (8 days)	34	<15	50	20	16	0	2	0.10
		16–25	50		14	0	6	0.09
		26–35	50		2	0	2	0.01
		36–45	50		2	0	1	0.01
Total			200	20	34	0	11	0.21

Table 6. *Stylochus mediterraneus*. Cumulative results of size-class experiments (Test 4; Table 5). There is a clear evidence of a preferential predation upon *Mytilus galloprovincialis* of less than 25 mm in length

	Mussel size-class (mm)				
	<15	16-25	26-35	36-45	Total
No. of mussels eaten per container	42	34	7	2	85
% of total eaten	49.4	40.0	8.2	2.4	100

We attempted to calculate the quantity of food ingested by each polyclad: 100 mussels, 16 to 25 mm in length (wet weight = 123.10 g), and 100 mussels 26 to 35 mm in length (wet weight = 410.00 g), were collected. Their soft parts were removed and kept in a thermostat at 110°C for 24 h; their dry weight was then measured. A mussel of 16 to 25 mm provides an average of 32 mg of food, while one of 26 to 35 mm provides 93 mg of food.

Calculated on the basis of the predation rate observed, the amount of food ingested by a polyclad preying on mussels from 16 to 25 mm in length would vary between 4.8 and 10.1 mg day^{-1} (average 7.1 mg day^{-1}) and the amount ingested by a day^{-1}) and the amount ingested by a polyclad preying on mussels from 26 to 35 mm in length between 6.5 and 15.8 mg day^{-1} (average 11.2 mg day^{-1}). These values were calculated on a sample of mussels collected in March 1977.

Discussion

As previously mentioned, *Stylochus mediterraneus*, despite its wide distribution along Italian shores (Galleni, 1976), has so far been known almost exclusively as an oyster predator. In the more recent works on Mediterranean oyster and mussel cultivation, no new findings are reported of this polyclad species which, owing to its large size, would be easily recognizable (see Korringa, 1976; Seed, 1976). At Leghorn and Trieste, *S. mediterraneus* is considered as a pest by the local fishermen and mussel farmers.

The ability to feed on different types of prey is one of the most interesting aspects of the biology of these flatworms. It is well known that many polyclads prey on animals belonging to different systematic groups. For instance, *Stylochus frontalis* feeds primarily on oysters but, if hungry, will also feed on barnacles (Pearse and Wharton, 1938). *S. ellipticus*, on the other hand, usually feeds on barnacles, but will also feed, at least in captivity, on fleshy parts of oysters (Pearse and Wharton, 1938). More detailed observations were made by Landers and Rhodes (1970), again on *S. ellipticus*. They ascertained that different populations of the same species feed on oysters or barnacles, respectively. In the laboratory, out of 7 populations examined, only 1 proved able to feed on both prey species; the other 6 fed only on those species on which they were collected in nature. These aspects of predation by *S. ellipticus* were confirmed by Christensen (1973). This behaviour, called by Landers and Rhodes "ingestive conditioning" recalls in certain aspects the behaviour observed in some polychaetes which are commensal with sea stars. In general, the host of the polychaete is strictly limited; however in some cases, as for example in *Arctonöe fragilis* (Baird), the worm may be commensal on more than one host, but each population is linked with a different species of sea stars. In these cases the annelid displays a response (chemotactic) only towards that species of sea star on which it normally lives (Hickock and Davenport, 1957).

This aspect of polyclad biology is probably true for *Stylochus mediterraneus*, which may exhibit different alimentary preferences related to the abundance of suitable prey in a particular locality. On shores where oysters are abundant, the flatworm feeds almost exclusively on these, while along the Tyrrhenian coast, where oysters are rare and mussels widespread, it feeds on the latter.

The mode of penetration of the worms into the prey shell and the ingestion of the fleshy parts is poorly documented. *Stylochus inimicus*, for instance, enters the shellfish by gliding between the two half-opened valves of the shell (Pearse and Wharton, 1938). *Balanus pacificus* Pilsbury is attacked by *S. tripartitus*, which inserts its pharynx between the opercular plates of the barnacle, digests the latter's muscles, and then penetrates the shell (Hurley, 1976). *Pseudostylochus ostreophagus*, however, makes a hole in the oyster shell with its pharynx and, after having digested the adductor muscle, penetrates easily between the half-opened valves and consumes the fleshy parts (Woelke, 1954, 1956, 1959; Smith, 1955).

The shells of mussels preyed upon by *Stylochus mediterraneus* are completely empty, with half-opened valves; no damage is visible to the walls, to the shell edges or to the ligament. The observation of some worms straddling the mussel shell at the level of its posterior adductor muscle suggests that *S. mediterraneus* may digest the muscle after having inserted its pharynx between the mussel valves.

The possibility cannot be ruled out that the worm in some way paralyses the mussel, rendering it incapable of closing its valves. Koopowitz (1970) indeed observed a slowing-down of the heart beat in the snail *Oxystele* sp. preyed on by *Planocera gilchristi*, which may be evidence of paralysis induced by the predator.

The preferential predation we have observed for small mussels further confirms the findings of Bytinski-Salz (1935), who reported, both in captivity and in nature, a preferential predation on younger oysters between 8 and 15 mm long. He also observed predation on larger oysters (up to 50 to 60 mm in length). In such cases, the oyster was usually infested by more than one polyclad. We also sometimes found up to 5 specimens of the flatworm on a larger mussel.

Although the method used to calculate the predation rate, i.e., the number of mussels eaten per polyclad per day, is adequate for comparison among mussels of similar dimensions, it is insufficient for comparison among mussels of different sizes or collected in different seasons. It does not account for the different amounts of fleshy parts which may vary with size of the prey, for the different physiological conditions at various times (e.g. sexual maturity) or, if the worm preys indifferently on more than one species (e.g. mussels or oysters), for the anatomical differences among the preys.

More complex calculation methods (see Hurley, 1976) do not seem to solve this problem completely. Furthermore, data on predation from various studies (Bytinski-Salz, 1935; Pearse and Wharton, 1938; Loosanoff, 1956; Woelke, 1959; Landers and Rhodes, 1970; Christensen, 1973; Lytwin and McDermott, 1976; Rho, 1976b) are not comparable because of the different methods used.

To avoid any within-test or between-test differences, we acclimatized the worms before each experiment, as suggested by Koopowitz (1970), and we tried as far as possible to use worms of about the same size. The care we took to acclimatize worms may perhaps explain the fact that we never observed a "first peak" in predation rate as reported by Landers and Rhodes (1970).

In some of our longer experiments (8 days), the predation rate was lower (0.07 and 0.09 mussels per polyclad per day, see Table 2) than in shorter experiments. This may be because polyclads which are not hungry do not necessarily feed twice during the duration of a test. Predation rate and observations still in progress suggest that *Stylochus mediterraneus* feeds every 6 to 8 days. The stability of the rate of predation observed during our tests using prey of the same size-class, suggests that the predation rate in nature may be similar.

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