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MEANDRINA MEANDRITES AND *EMBLEMARIOPSIS DIAPHANA*, FIRST RECORD OF AN ASSOCIATION BETWEEN A STONY CORAL AND A FISH, SIMILAR TO ANEMONE / FISH RELATIONSHIPS

by

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ABSTRACT

An association is described between a Caribbean stony coral, *Meandrina meandrites*, and a chaenopsid fish, *Emblemariopsis diaphana*. Like in anemone/fish associations the coral tentacles provide shelter for the fish. Some observations were made, both in the field and in the laboratory, of the behaviour of both fish and coral with respect to each other.

INTRODUCTION

The symbiosis between pomacentrid fishes (mostly *Amphiprion* species) and stoichactiid sea anemones in the Indopacific area is well known and extensively studied (cf. Mariscal, 1966, and Allen, 1975, for general information). Recently Albrecht (1977) described an association of about 30 fish species, mostly juveniles or inconspicuous species, seeking shelter between the tentacles of the anemone *Condylactis gigantea*, in the Caribbean.

Never, though, a similar symbiosis has been reported of a fish and a stony coral, although some coral species do have rather long tentacles. Such a relation however, if it exists, is likely to remain unnoticed, as most corals have their tentacles expanded only during the night. By chance, during a nightdive at the Curaçao reef, we had the good fortune to find a small fish between the tentacles of *Meandrina meandrites* (Linnaeus, 1758). After closer inspection many *Meandrina* appeared to be occupied by these fishes. This unique find compelled us to do some research after the nature of the relationship, the results of which are presented here. The fish belongs to the genus *Emblemariopsis*, Chaenopsidae (key to genera and species, cf. Stephens, 1963 and 1970), and proved to be *E. diaphana* Longley, 1927.

RESEARCH AREA

The majority of observations were made at the S.W. coast of Curaçao, Netherlands Antilles, about 1 km East of Piscadera Bay. Some field characteristics are given in fig. 1 and table I (after Butter, 1979). The current is usually East-West, the water is fairly clear (usually about 25 m visibility, sometimes 10 m).

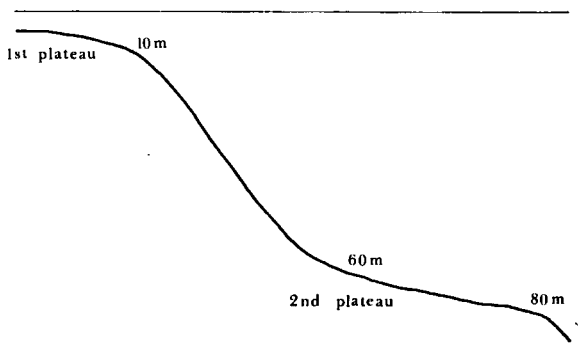

Fig. 1. Profile of the reef, East of Piscadera Bay.

Apart from this location the fishes were also seen immediately East of Piscadera (at night), on several colonies of *Meandrina meandrites*, between 10 and 20 m depth and one between the tentacles of *Eusmilia fastigiata* (Pallas, 1766) at 10 m depth. Further, occasionally, about 500 m West of Piscadera (by day) on *Meandrina*, between 10 and 20 m depth. Also, in Santa Marta,

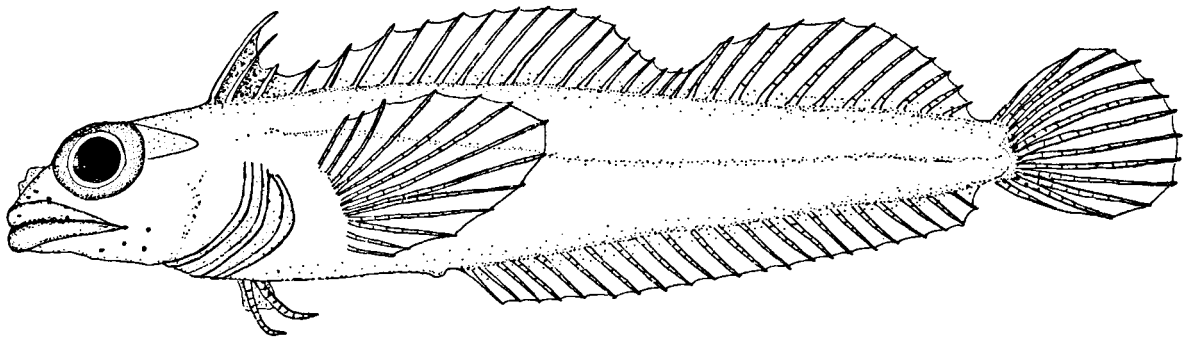

Fig. 2. *Emblemariopsis diaphana* Longley, 1927. Standard length 21 mm.

TABLE I

Composition of the reef East of Piscadera Bay, percentages of coverage.

	4½ m (%)	12 m (%)	22 m (%)	30 m (%)
Meandrina meandrites	19.9	6.4	3.8	3.9
Agaricia sp.	2.2	3.2	4.8	5.5
Montastrea sp.	3.0	15.1	9.6	17.7
Rock, sand, algae	57.0	67.4	72.1	69.6
Other	17.7 [1])	7.8	9.6	3.3

1) An important part hereof (6.6% coverage) is constituted of *Madracis mirabilis* (Duchassaing & Michelotti, 1861), at the other depths this species is entirely absent.

Colombia: one fish, apparently the same species, on *Meandrina*, at 20 m depth, during the day. In Curaçao *Meandrina meandrites* is a rather common species, in Santa Marta it is quite rare.

METHODS

Field observations were done with the aid of SCUBA gear. At night we used a diver's lamp. Specimens could be captured by putting a plastic bag around the coral and chasing the fish into it. The thus collected fishes were transferred to a container with seawater and transported to the laboratory for further examination or aquarium observation. For the latter, several tanks were set up with a sand bottom, with one *Meandrina* and two fishes in each. The next few days their behaviour was studied during the late afternoon, night and mid morning. For the nighttime observations we had to make use of artificial light, which we kept as low in intensity as possible, in order to keep the corals expanded and to minimize any other disturbing influences of the light.

RESULTS

1. PHYSICAL CHARACTERS OF THE FISH

Appearance (figs. 2-5). — Standard length of captured specimens varied from 11 to 21.5 mm, mean 16 mm and standard deviation 3 mm (of 28 specimens). Living fishes are translucent brownish, with red specks along the lateral line and the anal fin base. The anterior part of the dorsal fin has a heavier red pigmentation than the rest of the fin. There are red blots along the dorsal fin base and the visceral area has a red coloration. The eyes are heavily pigmented, very dark, being the most conspicuous part of the animal. Behind the eyes, on top of the head, is a dark patch. Under natural light conditions on the reef they seem to have the same colour as *Meandrina*. In alcohol or formalin they lose much of their pigmentation.

Stomach content. — Stomach contents were examined of specimens collected one to two hours after sunset, and of specimens collected from two hours before to two hours after sunrise. In most cases the stomach and esophagus were empty; if not, digestion was usually in an advanced stage. Small arthropods, diatoms, algae and polychaetes could still be recognized. See also table II.

Fig. 3. *Emblemariopsis diaphana* on *Meandrina meandrites*. Daytime, coral tentacles not expanded. Photograph Eric van Dijk.

TABLE II

Numbers and percentages of fishes with empty stomach and esophagus, in the early evening and in the early morning.

	early evening	%	early morning	%
empty	13	68.4	6	31.6
not empty	6	66.7	3	33.3

"Early evening" is about 1 to 2 hours after sunset, "early morning" refers to the period between 2 hours before and 2 hours after sunrise.
Most stomachs were empty, but 4 in the early evening and 3 in the early morning were in a stage of advanced digestion, whereas only in 2 cases in the early evening the fish appeared to have eaten recently.

E g g s . — Some specimens bore eggs. Each ovary contained about 20 eggs, diameter 0.2 to 0.5 mm. Of the 28 fishes examined, there were 6 ovigerous ones, their standard lengths were 13, 14, 14, 17, 20 and 21.5 mm.

2. BEHAVIOUR AND OCCURRENCE

2.1. On the reef, at night

T h e c o r a l . — By sunset *Meandrina* begins to expand its tentacles. During the whole night the coral is actively feeding, catching with its tentacles all kinds of swimming and suspended organisms. At night these are abundantly present in the vicinity of the corals. *Meandrina* tentacles are about 2 cm long, those of *Eusmilia* are somewhat longer.

If prey touches a tentacle it is captured immediately. Directly surrounding tentacles contract also and pull the prey into a stomodaeum for further consumption. In case of large prey a swelling remains visible at the colony surface. After a while the tentacles relax and expand again. The larger the prey, the longer the duration be-

Fig. 4. *Emblemariopsis diaphana* on *Meandrina meandrites*. Nighttime, coral tentacles expanded. Photograph Eric van Dijk.

tween contraction and re-expansion. The most peripheral tentacles expand first, the most central ones last. Any prey touching the tentacles evokes a contraction response; if capture fails (a rare occurrence) the tentacles re-expand immediately.

The prey consists of small shrimps, most of them about 3 mm, but also up to 15 mm, a lot of worms from 10 to 30 mm of which the larger ones are in mass comparable to the smaller commensal fishes, and many needle-like translucent animals of about 10 mm. Other fishes, in size comparable to the species under investigation, were not seen near *Meandrina*.

The fish. — Most fishes were found on *Meandrina*, with the highest density at a depth of 15 m. At 3-8 m they were very scarce, though *Meandrina* is abundant at these depths. Occasionally (in three cases) they occurred on *Eusmilia fastigiata* (Pallas, 1766), as can be seen in fig. 5, and it was seen once on *Colpophyllia natans* (Müller, 1775). These two species are not uncommon, but markedly less abundant than *Meandrina*. Small *Meandrina* colonies contained either few fish, or none at all. In large coral heads there were often more: up to ten individuals were sometimes occupying the same colony. Usually, the distance between them was not under 10 cm. Very small specimens were hardly visible; probably the densities, as presented in table III, are therefore underestimated.

Most of the time the fishes were hiding between the tentacles, at the bottom of an interstice between two ridges (fig. 4). Sometimes they moved on a few centimeters, or took position on top of a ridge; sometimes they emerged partly from the tentacles and then hid again between them (fig. 6). When threatened (hand movements of the investigators), they fled between the tentacles if they were outside of the colony.

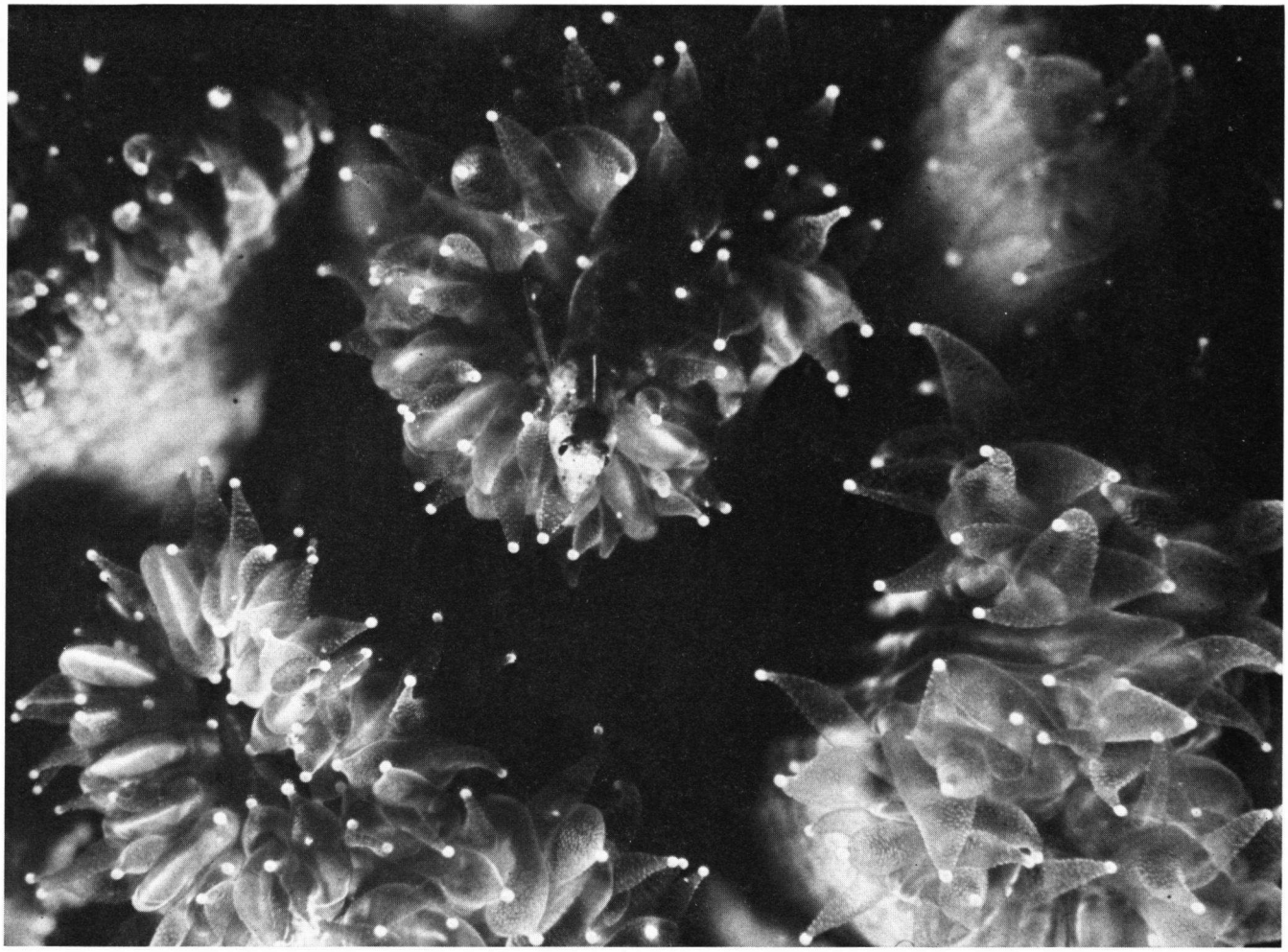

Fig. 5. *Emblemariopsis diaphana* on *Eusmilia fastigiata*. Nighttime, coral tentacles expanded. Protograph Eric van Dijk.

TABLE III

Counts of *Meandrina meandrites* at several depths and the number of fishes found on them.

	Number of fishes per coral					
	0	1	2	3	4	
depth (m)						
7½	11	—	—	—	—	1 to 2 hours after sunset
15	1	4	—	1	2	
22½	8	2	1	—	—	
7½	10	1	—	—	—	1 to 2 hours before sunrise
15	7	4	2	1	—	
22½	10	3	—	1	—	

In other dives, where corals were not systematically counted, we have found corals with many more fishes. The proportions in the beginning of the night do not differ significantly from those at the end of the night.

If they were on the colony, they just moved on a little, staying between the tentacles. To chase a fish away, out of the tentacles, one almost had to touch it, in such a way that the coral contracted its tentacles. Very small individuals reacted by hiding deep between the septs and could not be scared away, so it was not possible to capture them with our method.

When a fish stayed a while between the tentacles without moving, the tentacles slowly started to envelop it. Then the fish made a sudden movement and the tentacles relaxed again. When a fish was outside the colony, but within reach of the tentacles, the tentacles did not react. If at close distance prey was caught, the fish rapidly swam away.

Fig. 6. Hiding between the tentacles, coming out a little and hiding again. Characteristic type of behaviour.

Dead or anesthetized fishes, offered to the coral, were consumed, but slowly. A large swelling was visible at the colony surface after the fish was pulled inside, and re-expansion of the contracted tentacles took much longer than with regular prey.

2.2 On the reef, by day

Without artificial light it was much more difficult to distinguish the fish from the coral. Only the fish's eyes were perceptible. Also they fled more rapidly than at night. Very small ones crept between the septs, the bigger ones fled away from the colony. Consequently, far less fish were seen during the day than at night. As far as noted, they stayed on *Meandrina* between 10 and 25 m depth.

2.3 In the aquarium

For a global analysis the aquarium studies were divided in time units of 5 minutes per fish each, the behaviour was classed as active, moderately active and inactive. The time spent on each behavioural category was registered and also the time spent inside or outside of the colony.

Inactive behaviour can be described as follows: the fish stays motionless, except for the gills and the eyes, that move perpetually, the latter often independently of each other. Once in a while the anterior part of the dorsal fin moves up or down. By day, when displaying this inactive behaviour, the fishes were either on the coral, with their belly in an interstice between two ridges, or outside of it on the bottom, or against the wall of the aquarium. At night they stayed between the tentacles, usually in an interstice. Except for the movements already mentioned, they made casual sudden movements in order to relax the enveloping tentacles.

Moderately active behaviour involves the following types of behaviour:
(1) A small change of position, with intervals of 15 to 60 seconds. This behaviour was seen both during the day and the night. The fish remained motionless, suddenly moved a few centimeters and stood motionless again. The change of position took less than half a second. On the coral they moved along the interstice or out of it, to a position on top of a ridge, where they stayed a little while and then moved on to another (or the same) interstice. Fig. 7 shows a sequence of positions between the rapid movements.
(2) Turning the head. This behaviour occurred by day as well as by night.
(3) Snapping movements, possibly eating, without changing position. Only seen by day.
(4) Changing direction, without changing position, at intervals of 15 to 60 seconds. This behaviour occurred by day as well as by night.
(5) Change of colour as reaction on a congener. This was only seen in one tank, at night and in the late afternoon, whenever the other fish approached to a distance of less than 5 cm by night and less than 10 cm by day. In the other tanks no interaction was observed, not even if the fishes were at close distance.
(6) Coming out of the tentacles, looking around and retreating again (fig. 6). Only at night. The tentacles did not react to these movements, that were carried out very slowly.
(7) Swimming slowly along the bottom of an interstice. Observed at night only. The coral reacted by tipping the back of the fish with the end of its tentacles, one after another. It was only a slight touch, whereafter the tentacle resumed its original position.

Active behaviour includes:
(1) Moving short distances or changing direction, with intervals of less than 15 seconds. This behaviour is analogous to (1) and (4) of the moderately active behaviour, only the frequency is higher. Occurs by day as well as by night.

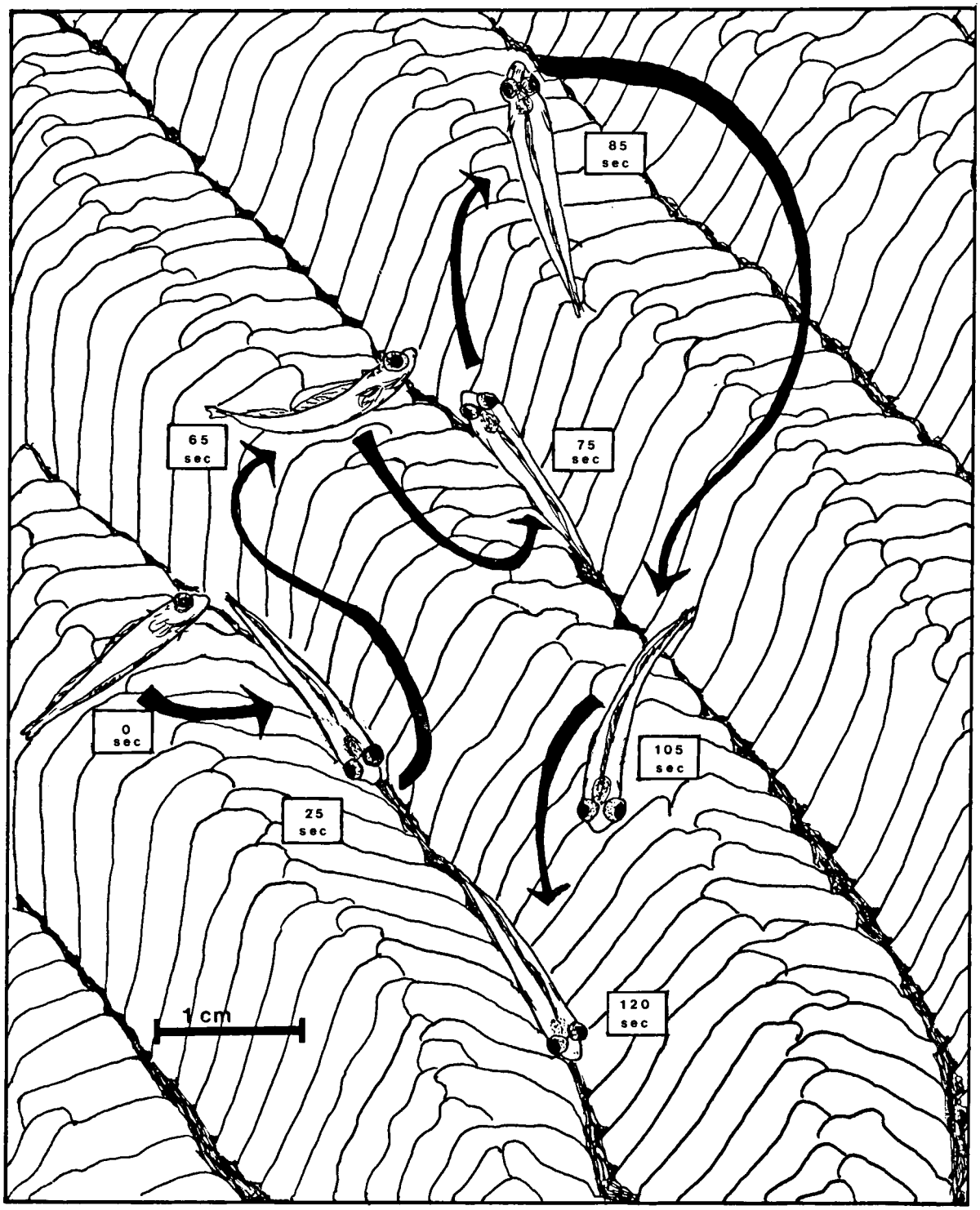

Fig. 7. A sequence of positions on the coral, as seen by day, in the aquarium. Characteristic type of behaviour.

(2) Moving distances greater than 5 cm at intervals of 0 to 60 seconds. Occurs by day as well as by night. They follow an erratic course across the colony, sometimes they leave the colony, stay off for a while, or return immediately. In general the movements are less rapid than the shifts over short distances or the changes of direction.

(3) Snapping movements together with change of position, foraging behaviour. Mostly seen during the day, but one time at night. Sometimes they follow an interstice, biting into the coral tissue, sometimes they swim across the sand bottom, biting into it, or they react to a particle suspended in the water, chasing after it.

(4) Aggression and flight. Only seen in one tank, both at night and during the day, but mainly in the beginning of an experiment. The first observations of this tank were made in the late afternoon of the second day after capture. That time most "incidents" were recorded: one fish kept chasing away the other one. Next day the territories were settled, the centers about 10 cm apart. By this time there was less aggression. A real fight never occurred, one fish (always the same one) darted towards the other one, that moved away immediately. The more aggressive fish most frequently changed colour, alternately becoming lighter and darker. Change of colour was also noted as an adaptation to the environment.

A survey of the time units spent on each of the behavioural categories is given in tables IV and V.

TABLE IV

Active, moderately active and inactive behaviour in the aquarium, recorded at 11 a.m., 5 p.m. and 11 p.m. (+, active behaviour; ○, moderately active behaviour; —, inactive behaviour).

protocol 1		protocol 2		protocol 3		protocol 4	
fish 1	fish 2	fish 1	fish 2	fish 1	fish 2	fish 1	fish 2
+	+	○	○	○	—	○	+
+	—	+	+	+	—	+	+
+	○	+	○	○	—	+	+
+	+	+	+	+	○	+	○
○	—	○	○	+	○	+	+
○	—	○	○	○	○		
		○	○				

protocol 5		protocol 6	
fish 1	fish 2	fish 1	fish 2
+	○	—	—
+	—	—	—
○	○	—	—
+	○	—	—
+	+	+	—
+	+	○	—
+	○	○	—
+	+		
○	○		

protocol 7		protocol 8		protocol 9	
fish 1	fish 2	fish 1	fish 2	fish 1	fish 2
+	—	○	—	—	—
+	—	○	—	—	—
○	—	—	—	○	—
○	—	○	—	+	○
○	—			+	+
○	○			+	—
○	○				
○	—				
○	—				

Protocols 1 to 4 are made about 11 a.m., protocols 5 and 6 about p.m. and protocols 7 to 9 about 11 p.m.

TABLE V

Time units spent on active, moderately active and inactive behaviour. One time unit is 5 minutes.

	11 a.m.	5 p.m.	11 p.m.
active	22	11	6
moderately active	20	9	15
inactive	6	12	17

A χ^2-test on the proportions is significant at the 0.005 level: evidently the fishes are more active during the day than at night. The time spent on the colony or away from it is given in table VI. These proportions also differ significantly at the 0.005 level. The fishes were always on the colony at night, in mid morning 81.4% of the time and in the late afternoon 57.1% of the time.

TABLE VI

Time spent on or outside the coral (in the aquarium), in time units of 5 minutes.

	11 a.m.	5 p.m.	11 p.m.
on the coral	39	18	38
outside the coral	9	14	0

CONCLUSION

There is a clear commensal relation between the fish, *Emblemariopsis diaphana*, and the coral, *Meandrina meandrites* (occasionally other coral species). Even in Santa Marta (Colombia), where *Meandrina* is rare, the fish seemed to be associated with this particular coral species. The coral behaves much less aggressive to the fish than to other organisms, the reason why is not yet understood. Although the adult fish may be too large a prey for the coral, the fact remains that it is not attacked and that small individuals are also left alone. Only when the coral is catching prey very close to the fish, it evades the snatching tentacles.

The less aggressive behaviour of the coral with respect to the fish might be explained partly by the fish's behavioural characteristics (the movements to induce relaxation of the tentacles), but it is possible that some chemical qualities of the fish's skin are also effective.

The aquarium studies indicate that the feeding periods of fish and coral do not coincide; this is in accordance with the field observations. The fish's advantage seems to lie in safe shelter, it might be possible that it eats coral tissue, although stomach contents consisted of a variety of organisms. Whether the coral benefits by this association is an open question.

The fish finds protection during the night; there are indications that also during the day it stays on or near *Meandrina*, but field observations are as yet too scarce to be conclusive. There is need for more research, both in the field and in an experimental environment.

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