ON THE GEOGRAPHICAL OCCURRENCE OF PELAGIC POLYCLAD TURBELLARIANS

by

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Résumé

Au cours de plusieurs expéditions dans les parties Sud et Centre de l'Océan Atlantique et dans la Mer des Sargasses a été récolté du plancton. Le réseau des stations de profils transatlantiques résultant de ces voyages montre la présence dominante des Polyclades *Planocera pellucida* dominantes, *Gnesioceros sargassicola* et *Chatziplana grubei*. *P. pellucida* n'apparaît qu'au Centre et au Sud de l'Atlantique, surtout, semble-t-il, au voisinage du Cap Vert. Cette hypothèse est rendue justifiée par la haute densité de population de l'espèce dans cette région. Dans la Mer des Sargasses on trouve régulièrement *G. sargassicola* et *C. grubei*. La présence de *P. pellucida* et *Ch. grubei* est liée à la température élevée de l'eau tropicale et subtropicale (20 °C et plus). On trouve également *G. sargassicola* dans des régions plus froides (à Woods Hole avec 2 °C en mars 1979). En tout, on connaît aujourd'hui 12 espèces pélagiques obligatoires ou facultatives.

P. pellucida, C. grubei, Acerotisa notulata, Parviplana californica et *Graffizoon lobatum* sont liées impérativement à une vie pélagique. L'auteur affirme la répartition mondiale de *P. pellucida*, mais semble pouvoir douter de la validité taxonomique surtout des populations du Pacifique Ouest.

Introduction

There had been a long controversy during the last century until intensive studies on pelagic polyclads by Graff (1892) and Plehn (1896) concluded that species like *Planaria velellae* Lesson, *Planaria oceanica* Darwin, *Stylochus mertensi* Diesing, *Stylochoplana tenera* Stimpson, *Carenoceraeus oceanica* Schmarda, *Stylochus pelagicus* Moseley, and *Planocera simrothi* Graff had to be synonymized with *Planocera pellucida* Mertens (cf. synonym list given by Faubel 1983). This list predicts that *P. pellucida* is the most common pelagic species distributed all over the warmer regions of the Seas. On the basis of these intensive reports it could not be expected that from new material species could be obtained being unknown to science. All together, until recencly 12 valid species of pelagic polyclad have been ascertained; they are treated according to their distribution and, in part, to their individual abundance as being obligate (a species with its main occurrence in this habitat) or facultative (a species with its occurrence also in some other habitats).

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Generally, polyclads are almost exclusively marine, the exceptions being three species of the limnic Indo-Malaysian region, and are worldwide distributed but more concentrated in tropical and subtropical areas.

Material and Methods

The material investigated was collected during the expeditions of the R.V. "Walther Herwig" in the Central and South Atlantic Ocean from November 1970 to April 1971 (for detail see John 1975,

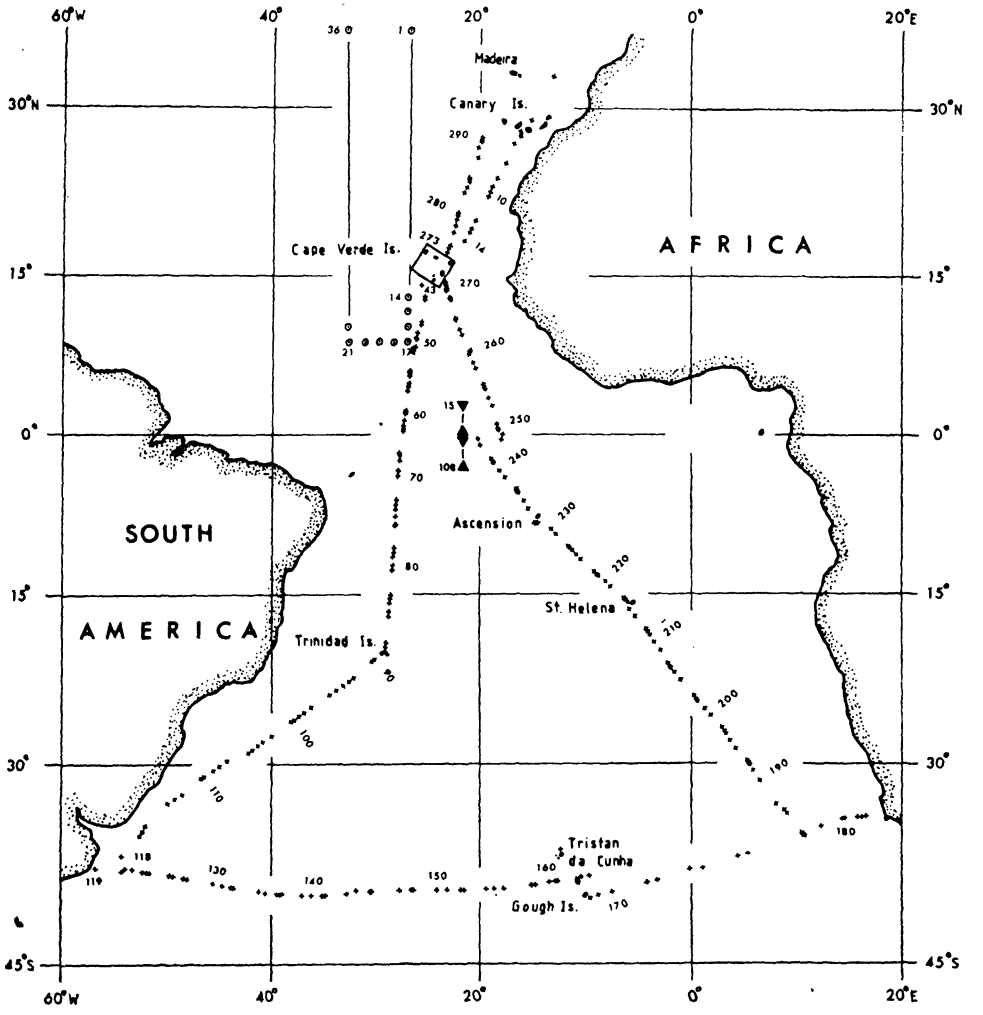

FIG. 1

Cruise track of R.V. "Walter Herwig" from November 1970 to April 1971 (+———+), of R.V. "Meteor" 51 from Februar to March 1979 (Δ———Δ), and of R.V. "Meteor" 60 from March to April 1982 (⊙———⊙), showing tow positions of the transects in the Central and South Atlantic Ocean (redrawn after John 1976-1977).

1976-1977) and of the R. V. "Anton Dohrn" from March to May 1979 along transects from Woods Hole (USA) to Bermuda, on a station grid within the Sargasso Sea, and from the Sargasso Sea to the British Channel (for details see John 1982). Furthermore, polyclads were obtained from neuston hauls sampled during both the expeditions of

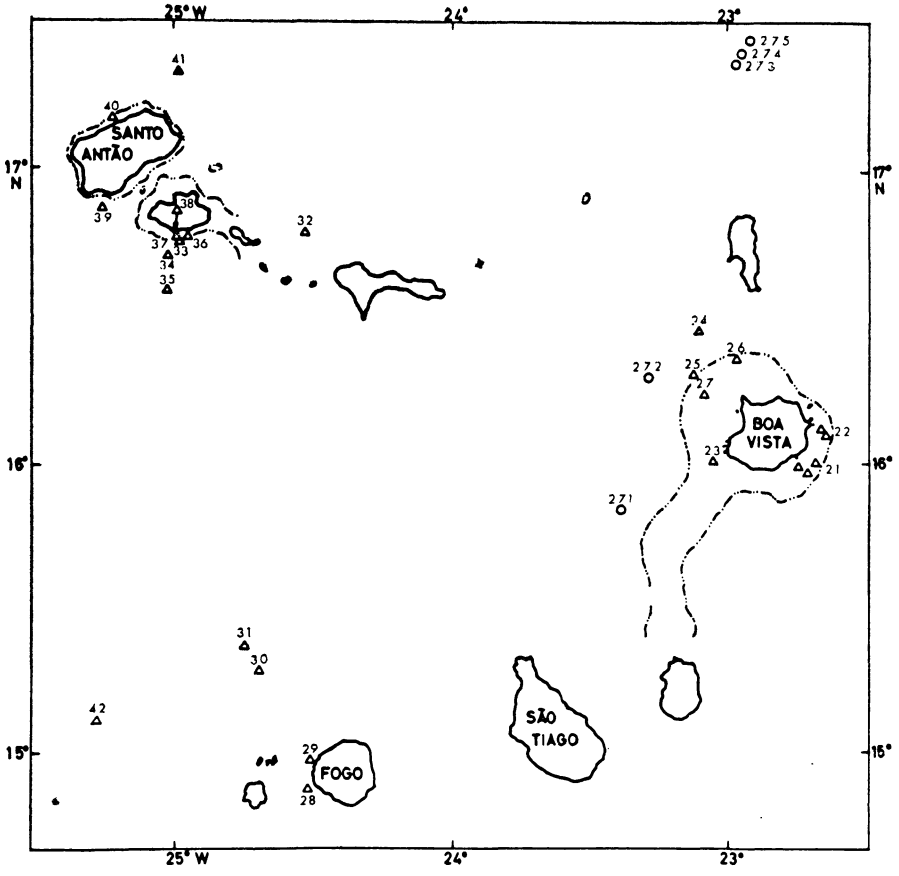

FIG. 2

The Cape Verde Archipelago (inset from Fig. 1), showing locations of tows during the cruise track of the R.V. "Walther Herwig" (redrawn after John 1981). Triangles: neuston samples from autumn (2-7 December); Circles: neuston samples from spring (17 April); interrupted line: 200m depth contour.

the R. V. "Meteor" 51 and 60 in the Central Atlantic Ocean from February to May 1979 and from March to April 1982 (for details see Andres and John *in press*), respectively. Generally, up to five tows were made each day, two tows during daylight hours and three tows at night whereas from the latter tows one was carried out at twilight just after sunset (John 1976-1977, 1982). From the cruise of R.V. "Walther Herwig" in the Central and South Atlantic Ocean the material investigated is based on the following neuston tows: 1-146, 184-272, and 285-290 (cf. Fig. 1).

Depending on the towing speed two types of neuston samplers were used. 1) A modified David Sampler (Hempel and Weikert 1972) with an upper and a lower net (opening 30×15cm) was towed at

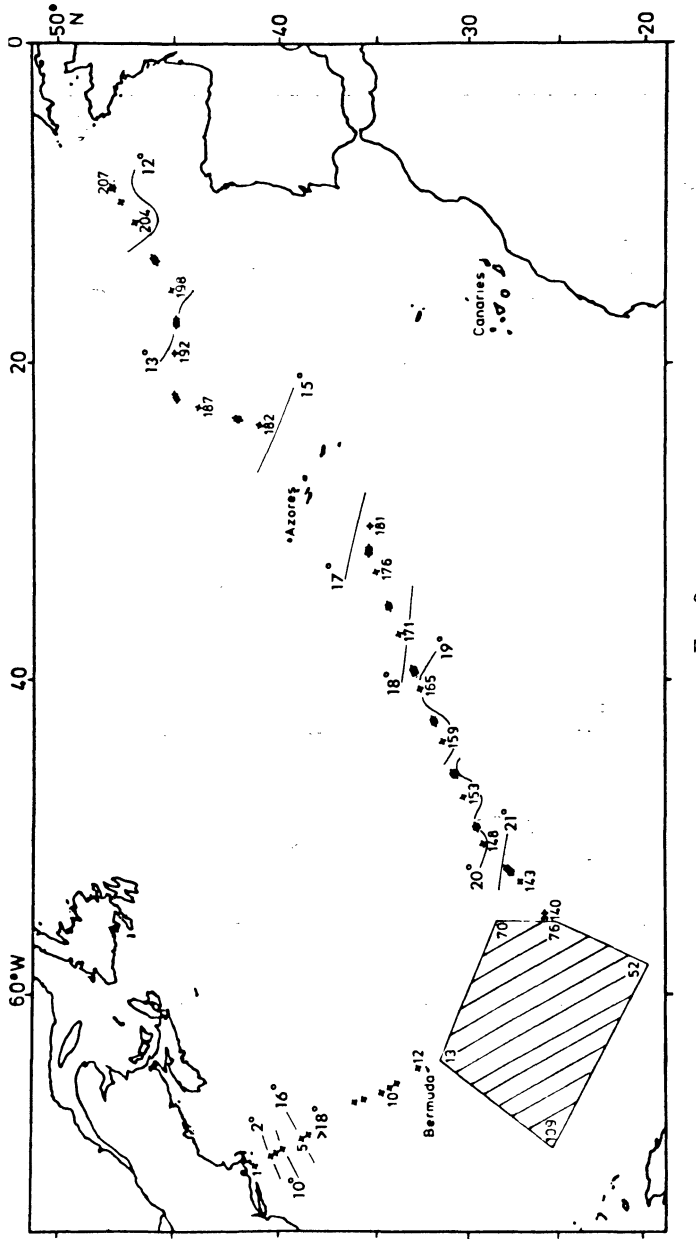

FIG. 3
Cruise track of R.V. "Anton Dohrn", showing tow positions of the transects from Woods Hole (USA) to Bermuda, to the Sargasso Sea, and from the Sargasso Sea to the English Channel from March to May 1979 (adapted from John 1982).

2-4 knots. The diving depth of the upper net is from the surface to about 8 or 10cm below. 2) A Highspeed Sampler (John 1975) having a net opening of 30×30cm, was towed up to about 7 knots. The diving depth of the net is from the surface to about 15cm below. The

Highspeed Sampler was only employed during the expedition of the R.V. "Walther Herwig" in 1970-1971. For more details of the use of the gear, sampling procedure, and measurement of surface temperature see John 1975, 1976-1977, 1982.

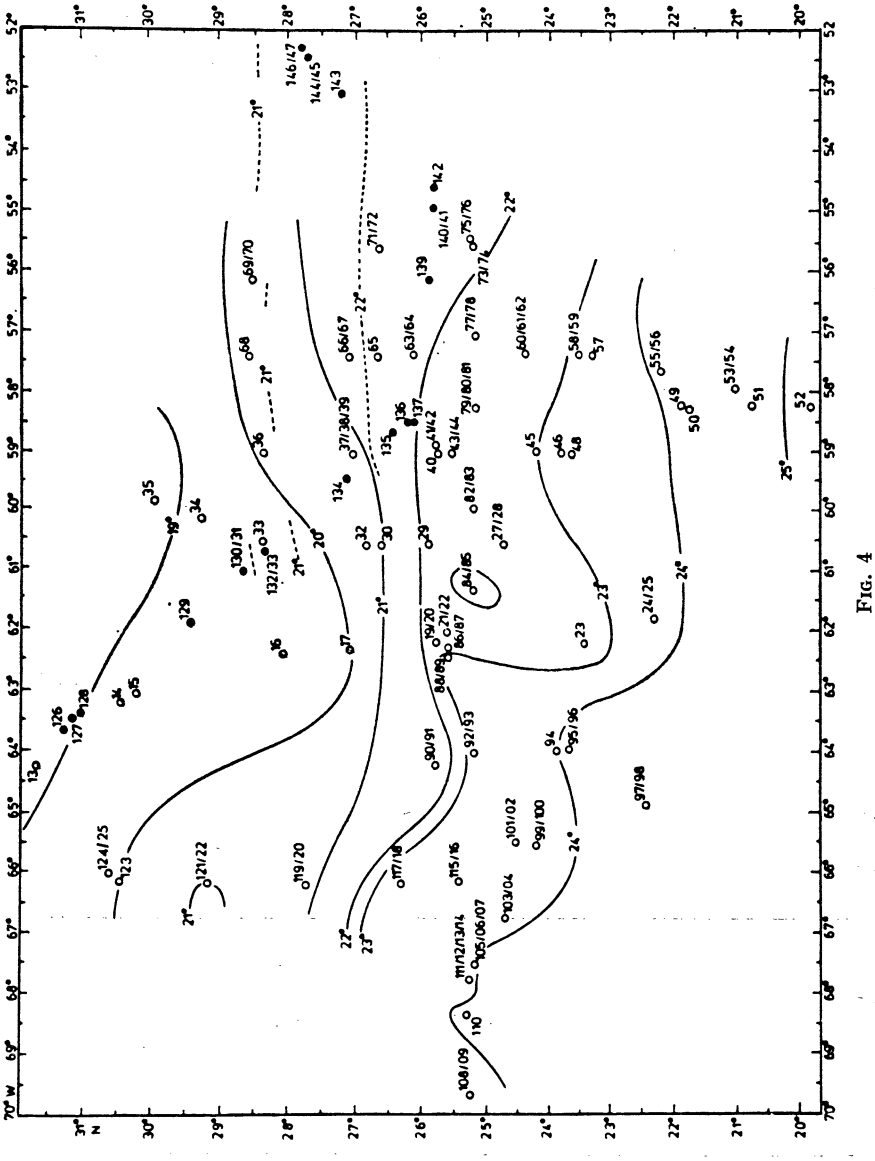

FIG. 4
The Sargasso Sea area (inset from Fig. 3), showing locations of tows taken during the cruise track of R.V. "Anton Dohrn". Circles and full lines represent haul positions and isotherms at the beginning of the cruise. Black dots and dashed lines represent haul positions and isotherms at the end of the survey (redrawn after John 1982).

The data presented in the figures and tables are related to average area of sea surface covered by the nets during the respective cruises. The neuston samples were fixed in 4 to 7 per cent formalin in seawater. The determination of the sorted specimens was based on squash preparations and serial sections.

RESULTS

The station patterns of the different cruises carried out in the Atlantic Ocean are listed in Figs 1-4. Figs 1 and 2 present the neuston tows of the Central and South Atlantic. In Fig. 3 and 4 the

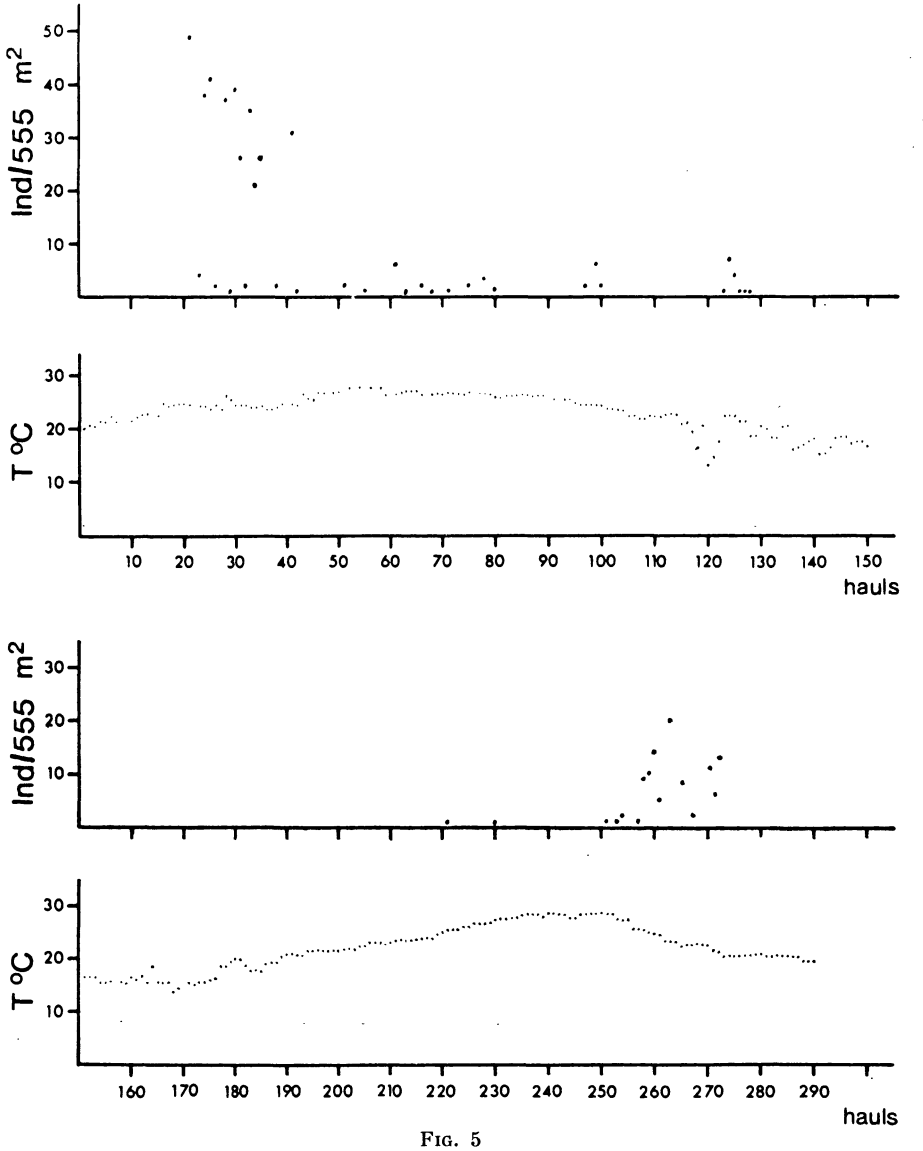

FIG. 5

Planocera pellucida.

Summary of individual abundance (ind./555m²) and the respective temperature (T°C) taken in the South and Central Atlantic Ocean from November 1970 to April 1971, R.V. "Walther Herwig".

stations of the neuston samples are included together with the ambient surface water temperatures encountered during the Sargasso Sea expedition. To both the pelagic regions, the South and Central Atlantic Ocean and the Sargasso Sea, definite polyclad assemblages may be assigned.

1) The South and Central Atlantic Ocean assemblage

In this region only *Planocera pellucida* (Mertens) was encountered. Numbers of individuals and values for temperature are compiled in Fig. 5 and Tables 1 and 2. *P. pellucida* is a common planktonic form and has no established association with any drifting element. Based on collections from a wide variety of stations the

TABLE 1

Planocera pellucida. Summary of positive sampling positions of the transects with the series available to me: Nos 15-29, 55-67, 96-108. Individual abundance is related to averaged 1924m² sea surface covered per towing cruise. The data were recorded during the expedition "Equatorial Up-welling", Meteor 51 in 1979.

haul number	φ	λ	Ind./1 924 m²
15	03°01'N	22°01'W	2
17	02°15'N	22°00'W	1
19	01°20'N	21°59'W	6
20	01°00'N	22°00'W	1
21	00°41'N	22°00'W	1
22	00°20'N	22°00'W	8
25	00°40'N	22°01'W	10
26	01°01'S	22°00'W	1
27	01°20'S	22°01'W	2
56	01°45'N	22°00'W	2
57	01°30'N	22°00'W	1
59	00°50'N	22°00'W	1
60	00°30'N	22°00'W	6
62	00°00'N	22°00'W	4
64	01°01'N	22°00'W	2
65	01°20'S	22°00'W	1
108	01°45'S	22°00'W	1

TABLE 2

Planocera pellucida. Summary of positive sampling positions of the transects with the haul series available to me: Nos 1-39. Individual abundance is related to averaged 577m² sea surface covered per towing cruise. The data were recorded during the expedition "Subtropex' 82", Meteor 60 in 1982.

haul number	φ	λ	Ind./577 m²
15	13°21'N	26°58'W	1
16	11°38'N	26°52'W	3
17	10°00'N	27°01'W	1
19	10°01'N	30°01'W	1
22	11°42'N	32°59'W	1

dominant distribution of this species extended from latitudes 17°N to 15°S in the equatorial region. On the transect of the western South Atlantic off South America (Fig. 1, 5), *P. pellucida* was sorted only from tows 71 to 80, 97 to 100, and 123 to 128, i.e. in the Brasil Current and the Convergence area between the Brasil Current and subantartic water masses (Lenz 1975). The consecutive series of

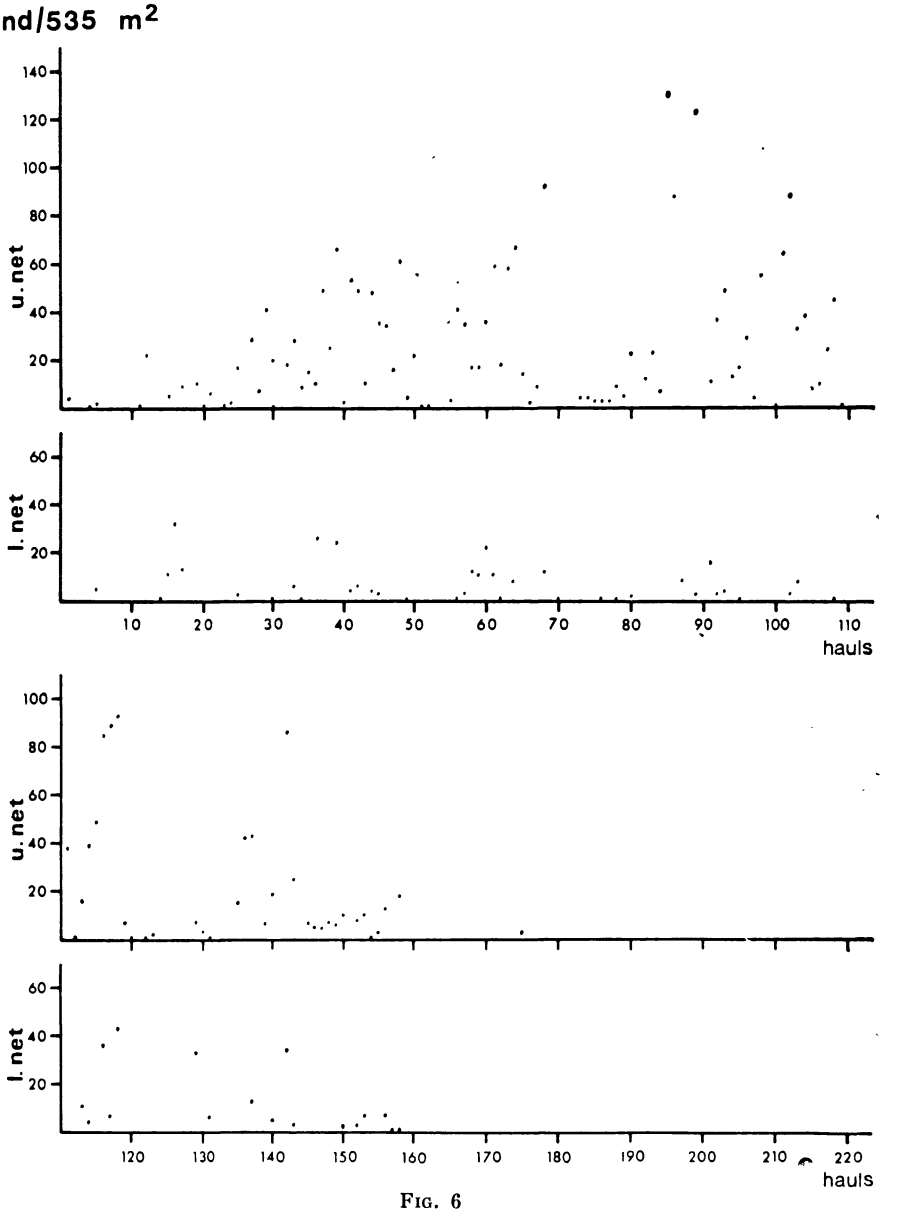

FIG. 6

Gnesioceros sargassicola.

Summary of the individual abundance (ind./535m²) of the hauls taken in the Sargasso Sea area from March to May in 1979, R.V. "Anton Dohrn". u. net=upper net samples; l. net=lower net samples.

tows from 129-146 and 184-250 were bare of any polyclads. The tows from 147 to 183 were not available to me.

It was found that the regions around the Cape Verde Islands were more densely inhabited (up to 48 ind. per 555m²) than were those collected from adjacent and western stations. The individual numbers of the latter tows varied between 1 and 10 per respective surface raea (Fig. 5, Table 1, 2). This distribution appeared to be restricted to water temperatures of 20°C or higher.

With respect to sexual maturity the population of *P. pellucida* looked rather different in different geographical regions. Tows taken in the Cape Verde Islands area comprised all stages of development both in autumn (Nov. 1970) and spring (April 1971). Small juveniles were more frequent than sexually mature adults. Farther south of this region the percentage of juveniles decreased and finally the number of adult individuals, e.g. in hauls 97-100 and 123-128 exceeded the number of juveniles.

2) The Sargasso Sea assemblage

In the Sargasso Sea area *Gnesioceros sargassicola* (Mertens) and *Chatziplana grubei* (Graff) are dominant representatives being associated with *Sargassum* (Fig. 6, 7). The geographical occurrence of *G. sargassicola* comprises the region covered by tows from haul 1 (off Woods Hole, USA) to haul 52 (the most southern one) and to haul 175 (the most eastern one) (Fig. 3, 4, 6). The occurrence of *Ch. grubei* determined by the haul pattern extends from latitudes 29° to 21°N and from longitudes 70° to 51°W in the Sargasso Sea area. Thus, *Ch. grubei* appears to be confined to water surface temperatures of 20°C or higher. *G. sargassicola,* however, obiously shows no preference to a distinct temperature range. It occurs in water masses of about 2°C off Woods Hole (Fig. 3, haul 1) as well as in regions with surface temperatures up to 25°C (Fig. 4, haul 51).

G. sargassicola was more conspicuously both in the number of positive tows (37 per cent) and in actual abundance (70 per cent) related to hauls 19-120 and 130-149 compared with *Ch. grubei.* In 176 tows the total number of *S. sargassicola* amounted to 3,332 individuals (19 ind. per tow as an average); in upper net samples were 2,844 individuals (16 ind. per tow as an average) and in the lower net 488 individuals (3 ind. per tow as an average).

In 152 tows 902 specimens of *Ch. grubei* were recorded (6 ind. per tow as an average). Of this total number 804 individuals were in 80 samples caught by the upper net (5 ind. per tow as an average) and 98 individuals were in 29 samples caught by the lower net (1 ind. per tow as an average). No tendency of change of abundance in the upper or lower nets in relation to the cycle of day and night could be established.

In all tows both *G. sargassicola* and *Ch. grubei* were represented by all stages of development. In relation to temperature or geographical occurrence there were no gradients detectable. Generally, the abundance of juveniles exceeded many times the abundance of sexually mature adults.

DISCUSSION

The holopelagic station pattern obtained by the different surveys in the Atlantic Ocean mentioned above is well suited to study the distribution of polyclads and to complete partly deficient results. Bock (1931) reviewed the bibliography up to this date, and Prudhoe

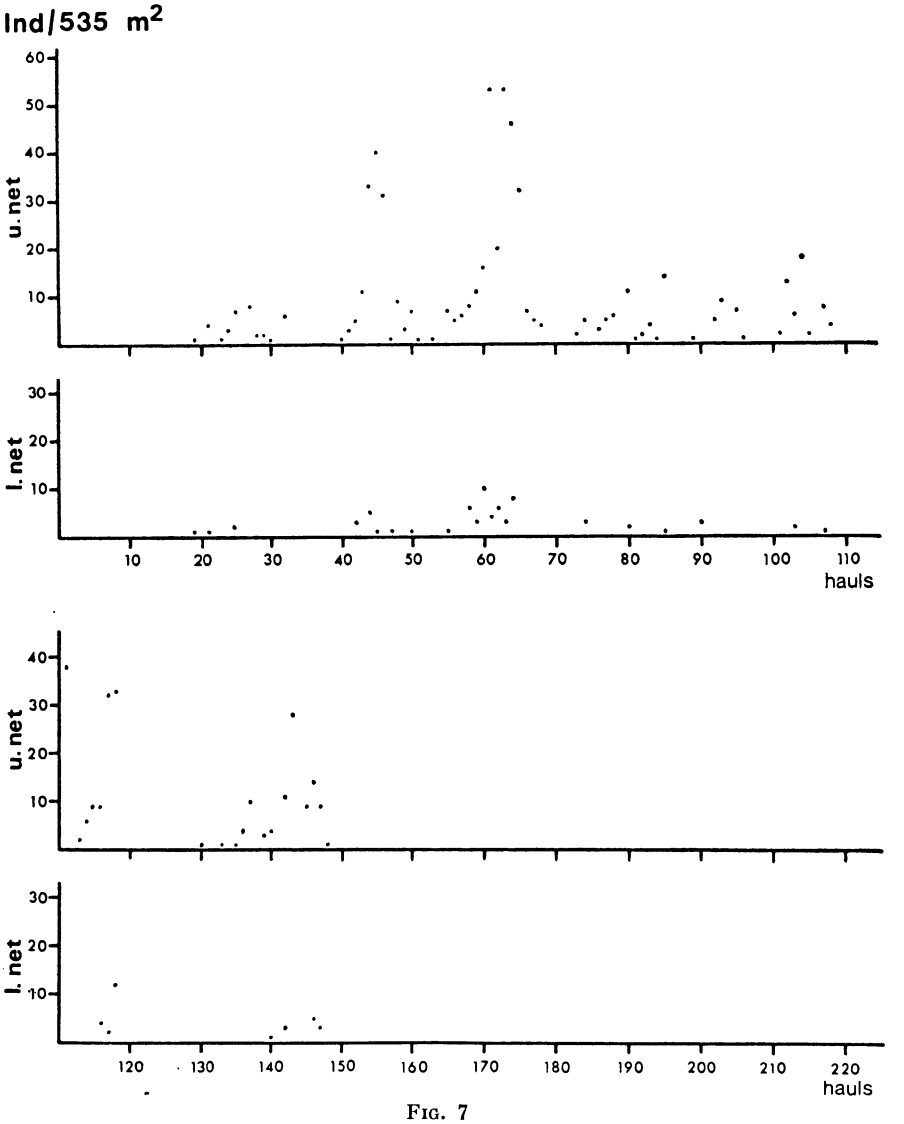

FIG. 7

Chatziplana grubei.

Summary of the individual abundance (ind./535m²) of the hauls taken in the Sargasso Sea area from March to May 1979, R.V. "Anton Dohrn". u. net=upper net samples; l. net=lower net samples.

(1950) reported on the geographical occurrence of *Planocera pellucida* in the Atlantic Ocean. The only other species, *Planocera simrothi* Graff, found in a Janthina shell off St. Helena, was synonymized with *P. pellucida* by Faubel (1983).

The geographical occurrence of *P. pellucida* concentrates in three areas in the Atlantic Ocean: 1) Cape Verde Islands region in connection with water masses of the North Equatorial Current, 2) distinct areas of the South Equatorial Current, Equatorial Countercurrent, Guinea Current, 3) Brasil Current. The warmer water masses of 1) belong to the North Atlantic circulation system and the water masses of 2) and 3) to the South Atlantic circulation system.

The prominent area of distribution of *P. pellucida* in the Atlantic Ocean is suggested to be the region around the Cape Verde Islands. This assumption is based on the high percentage of juvenile stages in that population, and because of the neighboured northern regions which are barren of *P. pellucida*. Therefore, the question arises what are the reasons which prevent that the whole population of *P. pellucida* does not float off by means of the North Equatorial Current? Obviously, a permanent or seasonal recruitment from nearshore or beach areas of the islands does not to exist (Graff 1892, Bock 1913, Prudhoe 1950). The tows which were made at immediate neighbourhood of islands of the archipelago (Fig. 2), were barren of any individuals (hauls 28, 36, 37, 40) or obtained only few individuals (hauls 22, 23, 29, 38, n=1—3), in contrast to the more distant tows (hauls 21, 24, 25, 27, 30, 31, 33, 34, 35, 41, 271, 272). The abundance of individuals increased with distance to the respective island. However, one has to consider that towing was not randomly patternd.

The occurrence in water currents distant from the Cape Verde Archipelago must be interpreted as a result of floating off from here with the different Equatorial Currents. Animals drifted with the North Atlantic Equatorial Current will mainain in the warmer North Atlantic circulation system. Another part of the floating Cape Verde Islands population might reach by the way of the South Equatorial Current (cf. Table 1; Fig. 5, hauls 70-80) the Brasil Current and possibly enrich the population of *P. pellucida* floating in the South Atlantic circulation system. Charts of Atlantic surface currents (e.g. Angel 1979, DHI 1967), however, do not suggest a direct link between the Cape Verde Current and the South Atlantic circulation system. On the contrary, the evidence of established assemblages of *P. pellucida* both in the total North and South Atlantic circulation systems of the warmer water masses could not be encountered up to recently.

The North Equatorial Current runs from the Cape Verde Islands area westwards and is confluent with the southern Sargasso Sea gyre. In this part of the North Atlantic circulation system *P. pellucida* was recorded only up to the region of longitude 42°W as the most western point. Hence, a closed circuit of the species in this system is not evident. The same holds for the South Atlantic circulation system where one has to consider that the transect from haul 120 to 180 was in subantarctic waters (West Wind Drift) having

temperatures below 20°C. The reason, for instance, for patchy occurrence of *P. pellucida* yielded by the transect from haul 123-128 is suggested to result in the phenomenon of permanent meander and eddies of subtropic and antarctic water bodies (Lenz 1975).

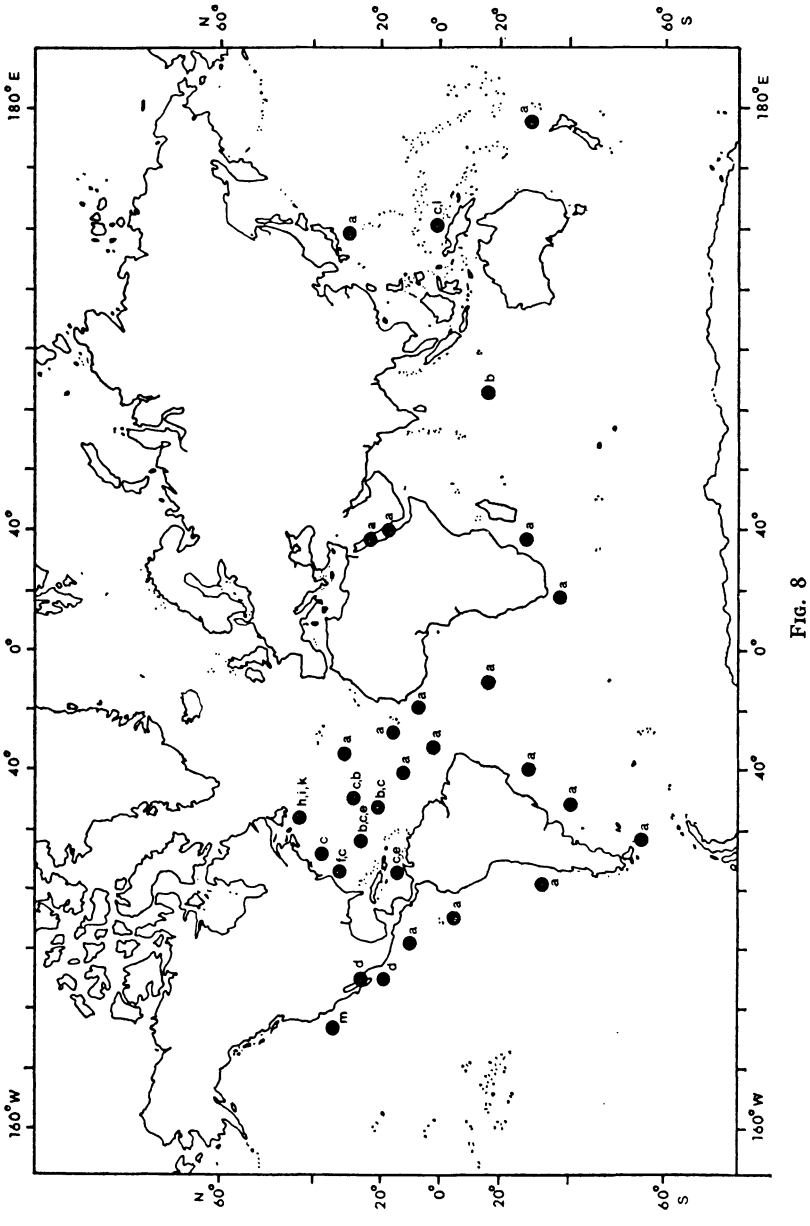

FIG. 8
Geographical occurrence of all pelagic polyclad *Turbellaria* known until recently. Letters represent species in Table 3.

For this reason the hypothesis is put forward that in the North and South Atlantic circulation system assemblages of *P. pellucida* are only established in water bodies with temperatures above 20°C and possibly these might be continually enriched with *P. pellucida* by

consecutive outflows of the Cape Verde Island population. In water masses having temperatures below 20°C *P. pellucida* assemblages probably perish. Verification of the situation and rectifying definitively spatial and perhaps temporal variation of *P. pellucida* within the North and South Atlantic circulation systems require sampling along additional distinct transects of tropical and subtropical water bodies of the Atlantic Ocean.

In the Sargasso Sea area *Gnesioceros sargassicola* and *Chatziplana grubei* are common polyclads (Plehn 1896, Timmermann 1932, Hyman 1939a, b, Prudhoe 1944, Weiss 1968, Fine 1970, Morris and Mogelberg 1973). According to Fine (1970) they belong to the *Sargassum* community. To this community does further the rare species *Acerotisa notulata* (Bosc) belong (Hyman 1939b, Morris and Mogelberg 1973) which could not be encountered in my material. The distribution of *Ch. grubei* is closely allied with that of the *Sargassum* weeds occurring in the Gulf of Mexico (Hyman 1939b) and the western North Atlantic (Sargasso Sea). *G. sargassicola* was also collected from eelgrass at Devil's Foot Island, Woods Hole, and found in Quisset Harbor, Buzzard Bay, on the bottom in 4-5 fathoms (Hyman 1939a), along the shore-line of Florida on weeds like Thalassia, Rhizophora, and Cymodocea (Marcus and Marcus 1968), on shores of the Caribbean Sea (Prudhoe 1944), and on sandy bottoms and seaweeds of Piscadera Bay, Curacao (Marcus and Marcus 1968).

TABLE 3

Compilation of the pelagic Polycladida with reference to their geographical occurrence being obligate (a species with its main occurrence in this habitat) or facultative (a species with its occurrence also in some other habitats) to this biotope. The running letters (a-m) are used for marking the occurrence of the respective species in Fig. 8.

species	obligate	facultative	references
a. *Planocera pellucida*	X		Mertens 1833, Graff 1892, Woodworth 1894, Plehn 1896, Bock 1913, 1923, 1931, Kato 1938
b. *Chatziplana grubei*	X		Graff 1892, Plehn 1896, Timmermann 1932, Hyman 1939b, Prudhoe 1944, Fine 1970
c. *Gnesioceros sargassicola*		X	Mertens 1833, Graff 1892, Plehn 1896, Timmermann 1932, Hyman 1939a, b, Prudhoe 1944, Adams 1960, Marcus and Marcus 1968, Fine 1970
d. *Parviplana californica*	X		Woodworth 1894, Cheng and Lewin 1975, Faubel 1983, Bosc 1801, Graff 1892, Plehn 1896, Hyman 1939b, Marcus and Marcus 1968
f. *Planctoplanella atlantica*		X	Hyman 1940
g. *Coronadena mutabilis*		X	Verrill 1873, 1882, Pearse 1938, Hyman 1940
h. *Pseudoceros velutinus*		X	Blanchard 1847, Lang 1884, Plehn 1896
i. *Prosthiostomum nationale*		X	Plehn 1896
k. *Notoplehnia nationalis*		X	Plehn 1896
l. *Stylochoplana challengeri*		X	Graff 1892, Prudhoe 1950
m. *Graffizoon lobatum*	X		Heath 1928

Considering the different distribution patterns of both these species there is no sure way of argumenting whether the spatial distribution pattern is due to a more established ability of ecological adaptation or whether the different occurrence is the result of seasonality of the great gyre of the Sargasso Sea. Actually, it appears that *Ch. grubei* is more restricted to the *Sargassum* weeds being within the gyre of the Sargasso Sea and the Gulf of Mexico than *G. sargassicola.*

In all, 12 valid species are known up to now which live in surface layers of the pelagic system being obligately or facultatively distributed (Fig. 8, Table 3). Obligately distributed (a species with its main occurrence in this habitat) in the holopelagial are *Planocera pellucida, Chatziplana grubei, Parviplana californica, Acerotisa notulata,* and *Graffizoon lobatum; Ch. grubei* and *A. notulata* are restricted to the western North Atlantic, *P. californica* and *G. lobatum* to the Baia California (Cheng and Lewin 1975, Faubel 1983) and Monterey Bay (Heath 1928), respectively. *P. pellucida* is reported being a cosmopolitan species (Graff 1892) and found in the Pacific Ocean (Plehn 1896, Woodworth 1894, Graff 1892, Bock 1923, 1931, Kato 1938), in the Indian Ocean (Bock 1913), and in the Red Sea (collected by John during Meseda I, 1977). The occurrence of *P. pellucida* east of Ushuaia (Argentina) confirmed by Bock (1913) could perhaps point to dispersal by means of attachment to vessels (cf. Gerlach 1977) but hardly to floating off from water bodies of the Brasil Current (Lenz 1975).

The specimens sampled in the Red Sea (John during Meseda I, 1977) were identified by dissection of the genital apparatus. The specimens had all the characters of true *P. pellucida.* However, the individuals caught off Japan which were identified by preparing sections by Kato (1938) exhibit essential individual characters being different from the type species (see Faubel 1983, p. 78-79). All other species found in the Indian Ocean and West and East Pacific Ocean were identified on the base only of whole mounts. However, an identification only based on morphological features is imposible as Kato (1938) demonstrated. Therefore, to clarify the question whether *P. pellucida* is a true cosmopolitan species, would require sampling on different transects of the Indian and Pacific Ocean and identification of the specimens by preparing sections.

Summary

On the basis of different expeditions to the South and Central Atlantic Ocean and to the Sargasso Sea, the geographical distribution of pelagic polyclads was determined. Prominent representatives of the Sargasso Sea area are *Chatziplana grubei* and *Gnesioceros sargassicola,* but only *Ch. grubei* is obligately restricted to this area and closely allied to *Sargassum* weeds. In the Central and South Atlantic Ocean only *P. pellucida* occurred. *P. pellucida* and *Ch. grubei* appeared to be confirmed to surface water temperatures of 20°C or warmer. *G. sargassicola* obviously shows no preference for a distinct temperature range. The prominent area of occurrence of *P. pellucida* is suggested to be the region around the Cape Verde Islands. This assumption is based on the high abundance, on the high percentage of juveniles stages, and because the neighbouring northern regions lack *P. pellucida.* The hypothesis is put forward that in the North and South Atlantic circulation system *P. pellucida* populations are only established in water bodies with temperatures above 20°C, and these might be continually

enriched by consecutive outflows from the Cape Verde Islands population. In all, 12 valid polyclad species are known up to now which are living in the pelagial of the different oceans. *Planocera pellucida, Chatziplana grubei, Parviplana californica, Acerotisa notulata,* and *Graffizoon lobatum* are distributed obligately in the holopelagial.

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