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Epiphytic Communities on Marine Plants of Seychelles, Indian Ocean, East Africa

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Abstract: Epiphytic communities on marine plants of Seychelles (Indian Ocean Island group associated with East Africa) were investigated in January - March of 1989 during the 15th biological voyage of the research vessel cademic Alexander Nesmeyanov. A seagrass species, *Thalassodendron ciliatum* and macroalgae (*Sargassum* spp. and *Halimeda* spp.) were tested for host substrates and biomass of their dominant epiphytes were assessed. Also, in order to understand the effect of shading and nutrient filtering by epiphytes, two series of photosynthetic rates were compared for *Th. ciliatum* host leaves having 10% and no epiphytes. Total of 84 species of algae and main taxons of benthic animals were identified from three different host plants. An average biomass of the epiphytes on *Th. ciliatum* was 184.6 g kg^{-1}, and dominant species were green alga *Halimeda opuntia* red algae *Dictyurus occidentalis* and *Gelidiella myrioclada*. These dominant species and their biomass were remarkably varied with depth increment. On *Sargassum* spp., an average biomass of the epiphytes was 0.18 g kg^{-1}, and the maximum biomass was never exceeded 0.16 g kg^{-1}. In the case of *Halimeda* spp. an average biomass of the epiphytes was 8.0 g kg^{-1}, and dominant species were *Peyssonnelia dubyi*, sponges and decapods. Photosynthetic rates of *Th. ciliatum* were significantly reduced in the leaves having 10% epiphytes (1.72 times lower, $t=6.718$, $p<0.001$).

Key words: Epiphytic communities, Macrophytes, *Thalassodendron ciliatum*, *Sargassum*

1. Introduction

Marine macroalgae are important substrates for attachment of other organisms and subsequently may increase the productivity of the coastal ecosystem. Seagrass leaves and short shoots also provide good substrates for numerous marine organisms such as sessile algae, hydrozoa, bryozoa and sponges (Larkum *et al.* 1989). Besides sessile organisms, a number of motile animals such as fish and crustacean use the seagrass beds and macroalgal forests as their habitats and nutrition sources (Kendrick *et al.* 1988; Makkaveeva 1979; Orth and van Montfrans 1984; Seed and O onnor 1981).

These organisms are called piphytes and, in this study, they are categorized into two groups; 1) the phytophilous motile animals using the plants as their habitats and food (epifauna), 2) the epiphytic plants and animals using the host plants as their substrates for growth and attachment (epiflora). Epiphytic algae play an important role in primary production as is their host. Their annual primary production, when compared to the host, can account for 17% in temperate waters (Vaughan 1982) and up to 22% in the tropics (Johns

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1968). However, these epiphytes affect their host plants by shading the light, damaging the leaf blades, and filtering the nutrients (d ntonio 1985).

Up to date, a number of studies on the epiphytic biology and ecology of marine plants have been conducted (Carlos *et al.* 1996; Hemminga *et al.* 1995; Jones 1968; Larkum *et al.* 1989; Taylor and Lewis 1970; van Montfrans *et al.* 1984; Ohgai and Takesue 1987). However, data on the seagrass *Thalassodendron ciliatum* and macroalgae of East African are limited.

In this paper, characteristics of the epiphytic communities on *Th. ciliatum* and macroalgae in Seychelles, East Africa, are reported which was investigated during the period of 15th biological voyage of the research vessel cademic Alexander Nesmeyanov during January - March of 1989. The adverse effects of epiphytes are also reported on the basis of the results comparing the photosynthetic rates of two *Th. ciliatum* host leaves having 10% and no epiphytes, respectively.

2. Materials and Methods

Epiphytic communities on the marine plants in Seychelles, an Indian Ocean Island group associated with East Africa island chains, were investigated during January - March of 1989 (Fig. 1). *Thalassodendron ciliatum*, the common seagrass of the area and two types of macroalgae (*Sargassum* spp. and *Halimeda* spp.) were tested for the host substrates. Samples were collected from the depth ranging 0-20 m using SCUBA, and total 36 quantitative and 15 qualitative samples were taken. For a quantitative analysis, all host plants from the area measuring 0.25 m^2 of typical seagrass or macroalgal beds were removed, selected, and transported to a laboratory using a gas mesh. Samples were processed according to the hydrobiological methods (Methods for Study of Marine Benthos 1971). Epiphytic biomass was separated form the host plants and weighed; all data were standardized to per 1 kg of host biomass.

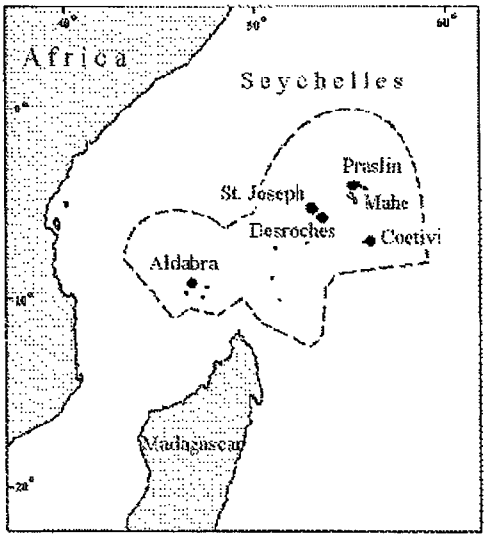

Fig. 1. Map showing the study areas (black circles).

For the seagrass *Th. ciliatum*, data were compared between deferent age groups. For the comparison, 10 leaf sockets were selected from every sample, and crustose algae and animals covering the hosts were calculated.

For studying the effect of shading and nutrient filtering by epiphytes, photosynthetic rates were compared between two *Th. ciliatum* host leaves having 10% and no epiphytes; photosynthetic rates were measured using radiocarbon analysis (Kolmakov and Tarankova 1978).

Marine algae were identified using the methods described in Kalugina-Gutnik *et al.* (1992), Titlyanova *et al.* (1992) and Wynne (1995).

3. Results and Discussion

Epiphytic Community of *Thalassodendron ciliatum*

Epiphytes on *Th. ciliatum* were investigated in the lower intertidal of St. Joseph Island and in the subtidal of Coetivy Island. A total 63 species (Cyanophyta: 1, Rhodophyta: 49, Phaeophyta: 2; Chlorophyta: 12) (Table 1) of macroalgae and main taxons of benthic invertebrates were observed.

In the lower intertidal zone, the dominant epiphytic algae were green algae *Dictyosphaeria cavernosa* (9.5 g kg^{-1}) (Table 2). Dominant epi-

Table 1. Taxonomic composition of macroalgae - epiphytes of community *Thalassodendron ciliatum* (1), *Sargassum* spp. (2)

Taxon			
Cyanophyta			
Lyngbya confervoides Ag.		+	
L. majuscula (Dillw.) Harv.	+		
Oscillatoria [illegible] Hauck			+
Rhodophyta			
Acrochaetium seriatum Borg.	+		
Anotrichium tenue (C. Ag.) Näg.			+
Antithamnion [illegible] Näg.	+		
Botryocladia skottsbergii (Borg.) Levr.	+		
Caloglossa adnata (Zanard.) De Toni	+		
Centroceras clavulatum (C. Ag.) Mont.			+
Ceramium brevizonatum var. *caraibicum* H. Peters. et Borg.	+		
C. flaccidum (Wall. ex Kütz.) Harv. (= *C. taylorii* H. Petersen)	+		+
C. gracillimum (Kütz.) Zanard.	+	+	+
C. macilentum [illegible]	+		
Ceramium sp.	+		
Champia parvula (C. Ag.) Harv.	+		
Chondria repens Borg.	+		
Chrysymenia pyriformis Borg.	+		
Coelarthrum boergesenii W. v. Bosse	+		
Corallophila apiculata (Yam.) R. Norris (= *Centroceras apiculatum* Yam.)			+
Crouania attenuata (Bonnem.) J. Ag.	+		+
Dasya mollis Harv.	+	+	
Dictyurus occidentalis Borg.	+		
Erythrotrichia carnea (Dillw.) J. Ag.	+	+	
Falkenbergia hillebrandii (Born.) Falk.		+	
Fosliella farinosa (Lam.) Howe	+		
Gelidiella adnata Dawe	+		
G. bornetii (Kütz.) J. Feldm. et Hamel	+		
G. myrioclada J. Feldm. et Hamel	+	+	
G. pannosa J. Feldm. et Hamel	+		
G. sanctarum J. Feldm. et Hamel	+		
Gelidiopsis [illegible] Tseng	+		
G. subcylindrica Okam.	+		
G. weber-van-bosseae Borg.	+		
Haliptilon subulatum (Ell. et Sol.) Johan.	+		
Herposiphonia secunda (C. Ag.) Ambronn f. *tenella* (C. Ag.) Wynne	+		
H. tenella (C. Ag.) Wynne (= *H. secunda*)	+		+
Hypnea aspera Borg	+		
H. nidulans Setch.		+	
H. pannosa J. Ag.	+	+	+
Hypoglossum attenuatum Gardn.	+	+	
Jania capillacea Harv.			+
J. ungulata (Yendo) Yendo f. *brevior* (Yendo) Yendo		+	+
Laurencia papillosa (Ag.) Grev.	+		
L. parvipapillata Tseng	+		+
L. pygmaea W. v. Bosse	+		
Leveillea jungermannioides (Hering et Martens) Harv.		+	
Liagora ceranoides Lam.	+		
Lomentaria mauritiana Borg.			+
Lophocladia trichoclados (C. Ag.) Schmitz	+		
Lophosiphonia villum (J. Ag.) Setch. et Gardn.	+		+
Peyssonnelia dubyi Crouan	+		
Pleonosporium borreri (J. E. Smith) Näg.	+		
Pterocladia caerulescens (Kütz.) Santel.	+		
Polysiphonia crassa Tseng	+		
P. subtilissima Mont.	+		
Rhodymenia [illegible] W. v. Bosse	+		
Spyridia [illegible] (Zanard.)	+	+	
Taenioma perpusillum (J. Ag.) J. Ag.	+		
Tolypiocladia glomerulata (Ag.) Schmitz			+
Wurdemannia miniata (Duby) J. Feldm. et Hamel	+		
Phaeophyta			
Dictyopteris delicatula Lam.		+	
Dictyota friabilis Setch.	+		
Hincksia breviarticulata (J. Ag.) Silva		+	
H. mitchelliae (Harv.) Silva		+	
Lobophora variegata (Lam.) Womers.			+
Sphacelaria rigidula Kütz. (= *S. furcigera*)	+	+	
Chlorophyta			
Anadyomene wrightii Harv. ex J.E. Gray	+		
Boodlea struveoides Howe	+	+	
Cladophora laetevirens (Dillw.) Kütz.			+
C. socialis Kütz.	+		
Dictyosphaeria cavernosa (Forsskål) Børg.	+		
Enteromorpha clathrata (Roth) Grev.		+	
Halimeda micronesica Yam.	+		
H. opuntia (L.) Lam.	+		
H. stuposa W. Taylor	+		
Halimeda sp.	+		
Microdictyon okamurae Setch.	+	+	
Rhizoclonium implexum (Dillw.) Kütz.		+	
Struvea anastomosans (Harv.) Picc. et Grun.	+		
Ulva rigida C. Ag.		+	
Valonia aegagropila C. Ag.	+		
Valoniopsis pachynema (Mart.) Borg.	+		

phytic animals were Echinodermata (35.4 g kg^{-1} or 71.5 inds. · kg^{-1}) and Gastropoda (33.0 g kg^{-1} or 56.5 inds. kg^{-1}). Biomass of other animals such as Crustaceans and Tunicates were much lower. The total biomass of the epiphytes was 84.3 g kg^{-1} (164 inds kg^{-1}). Epifauna were represented by detritophages, living in rhizomes of the *Thalassodend- ron* bed. During the study period, the maximum tides were observed which completely exposed the littoral zone. It promoted the atrophy of *Thalassodendron* and, probably, the loss of some epibionts as well as migration of the motile forms from the upper sublittoral zone.

The dominant epiphytes at 1 m depth were red algae (90.4% of total biomass), among which *Gelidiella myrioclada* was the most abundant with the biomass of 18.5 g kg^{-1} (Table 2). Bases of the epifauna were made up of sponges (1.5 g kg^{-1}). Gastropods (*Mitrella* spp. and *Nerita* spp.) and amphipods dominated numerically with densities of 36 and 20 inds: kg^{-1}, respectively. The quantitative characteristics of polychaetes and decapods are somewhat lower (till 16 inds: kg^{-1}). The total biomass of community does not exceed 25 g kg^{-1}. The bio-

Table 2. Biomass (B, g kg^{-1}) and abundance (A, inds. kg^{-1}) of epiphytes on *Thalassodendron ciliatum* in the lower intertidal zones of St. Joseph Island (depth 0-1 m) and in the subtidal zones of Coetivy Island (depth 3-10 m).

Taxon	Depth(m)									
	0 m				1 m				3 m	
	5 m		10 m							
Rhodophyta										
Dictyurus occidentalis	-	-	-	-	136.36	-	1.06	-	5.46	-
Fosliella farinosa	-	-	-	-	-	-	-	-	-	-
Gelidiella myriocladа	-	-	18.5	-	-	-	-	-	-	-
Griffithsia subcylindrica	-	-	-	-	14.69	-	-	-	-	-
Haloplegma duperreyi	-	-	-	-	26.68	-	0.12	-	11.34	-
Herposiphonia crispella	-	-	-	-	-	-	-	-	0.04	-
Peyssonnelia dubyi	-	-	-	-	-	-	-	-	0.29	-
Chlorophyta										
Dictyosphaeria cavernosa	9.45	-	-	-	-	-	-	-	-	-
Halimeda opuntia	-	-	-	-	1.08	-	-	-	17.74	-
Microdictyon okamurae	-	-	-	-	0.11	-	-	-	0.52	-
Spongia	-	-	1.45	-	8.43	-	55.1	-	64.27	-
Coelenterata	-	-	+	-	0.42	-	+	-	0.24	-
Polychaeta	-	-	0.02	16	0.07	-	5.31	-	0.14	-
Sipuncilidea	-	-	-	-	-	-	-	-	0.07	9
Isopoda	-	-	-	-	0.01	14	0.03	29	+	1
Amphipoda	+	9	0.02	20	0.03	28	0.02	24	+	4
Decapoda	3.24	27	0.34	16	-	-	-	-	0.25	8
Gastropoda	33.00	56.5	0.25	36	0.06	7	0.10	24	-	-
Bivalvia	-	-	-	-	-	-	+	5	-	-
Bryozoa	-	-	+	-	+	-	+	-	273.14	-
Echinodermata	35.36	71.5	-	-	-	-	-	-	-	-
Tunicata	3.29	-	-	-	-	-	3.33	-	1.43	-
Total	84.34	164.0	20.58	88.0	197.94	49	65.07	82	374.93	22

mass of epiphytic red algae at 3 m depth reached up to 99.3 % of total biomass. *Dictyurus occidentalis* dominated at this depth with a biomass of 136.4 g kg^{-1}. *Haloplegma duperreyi* and *Griffithsia subcylindrica* with 26.7 and 14.7 g kg^{-1} in biomass, respectively, were notable among subdominants. Various systematic groups represented the fauna of epibioses. Sponges (8.4 g kg^{-1}) made the basis of biomass at depth 3 m. The proportion of main animal epiphytic groups was not great; their total biomass did not exceed 0.5 g kg^{-1}. Amphipods dominated numerically with 28 inds: kg^{-1}. A total density of the motile forms weighed 49 inds. kg^{-1}. Domi- nating species changed with increasing depth. At depth of 10 m, the biomass of green algae reached up to 51.6 % of epiphytic algae. *Halimeda opuntia* dominated with a biomass of 17.7 g kg^{-1}. Despite of specific diversity of red algae, their total biomass was reduced down to 17.1 g kg^{-1}. Total biomass of epiphytic algae was reduced with increasing depth. However, epifauna biomass in an epibiosis increased with the increasing depth. Bryozoans dominated at depth of 10 m (273.1 g kg^{-1}), sponge biomass increased up to 64.3 g kg^{-1}. Biomass of the motile forms was reduced, and their total density was 22 inds: kg^{-1}).

From the comparison between age groups of *Th. ciliatum*, which was represented by red algae *Griffithsia* spp. and *Fosliella farinosa*. The fauna groups such as hydroids, bryozoans and sponges were usual. There was a quite often settlement of spirorbid polychaetes (up to 20 inds: kg^{-1}) with 0.7 - 1.0 mm in diameter in sinuses of

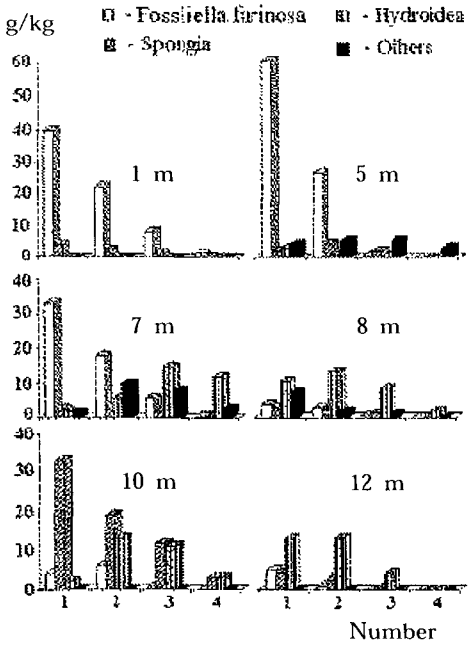

Fig. 2. Changes in relation of the epiphyte biomass of *Thalasso- dendron ciliatum* by depths. On abscissa - leaf number; on ordinate - biomass, g kg^{-1}.

the leaves. The considerable covering of the leaves was made by the red alga *F. farinosa* and sponges at 1 m depth. The greatest cover (up to 44 %) was marked on the 1-st leaf at the expense of *F. farinosa* development (Fig. 2). Area covered by incrusted organisms was reduced with decreasing age of the leaves. The youngest 5 -th leaf being in a rudimentary state of growth was not covered by epiphytes.

The covering of leaves varied at limits of 2.2 - 9.1 % at 5 m depth. The greatest cover was observed on the 1-st and 2 -nd leaves at the expense of mass development of hydroids. At 12 m depth, sponges gave the greatest leaf covering. Projective covering of sponges varied from 2.5 to 18 % on the leaves of *Thalassodendron ciliatum* from the 1-st to 4-th leaves, accordingly. The biomass of hydroids, in comparison with sponges, was much lower. The poorest covering (1 %) was observed on the 1-st eliminating leaf. Hydroids showed a maximal covering (12 %) in epibiosis on the 2-nd leaf. There was a lowering intensity of young leaf covering. Red algae biomass was inappreciable, i.e., the square of covering did not exceed 1 % including the 1-st leaves (Fig. 3).

Epiphytic Community of *Sargassum* spp.

Epiphytes on three *Sargassum* species (*S. turbinarioides, S. ilicifolium* and *S. muclure*) were investigated in the sublittoral zone of Praslin Island. The 22 species of epiphytic algae were collected from the study area (Cyanophyta - 1, Chlorophyta - 6, Phaeophyta - 3, Rhodophyta - 12 species) (Table 1). Species in this community did not reach significant biomass. Biomass of each species did not exceed 0.1 g/kg, and the epifauna was represented only by motile forms. At 1 m depth, majority of epibiosis was made by isopods with 59 inds. kg^{-1} density settlement. Despite of high density, its biomass was insignificant (Table 3). Among sub-dominant species, amphipods were com-

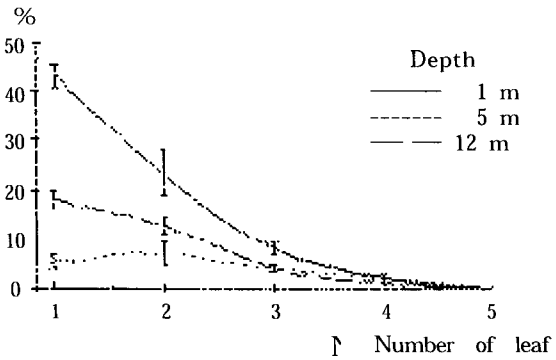

Fig. 3. Changes of *Thalassodendron ciliatum* leaves with epiphyte coverings with depth. For abscissa - leaf number; for ordinate - leaf coverings by epiphytes,

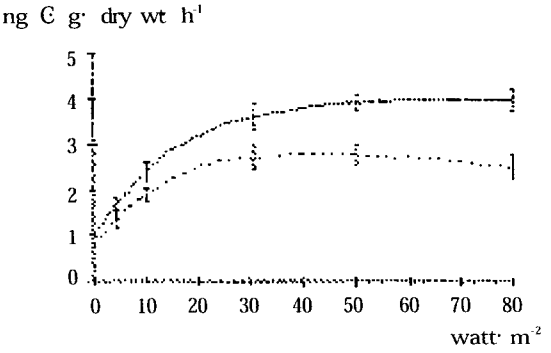

Fig. 4. Changes in photosynthesis by *Thalassodendron ciliatum* leaves with 10 % epiphyte covering (dotted line) and without epiphytes (continuous line). For abscissa - illumination, wt· m^{-2} per hour; for ordinates

Table 3. Biomass (B, g· kg^{-1}) and abundance (A, inds. kg^{-1}) of epiphytes on *Sargassum* spp. in the sublittoral zones of Praslin Island.

Taxon	Depth (m)					
	1 m		5 m			
Coelenterata		+		-		
Polychaeta	+		-			
Isopoda		0.02		+		
Amphipoda	+		+			
Decapoda		0.10	59			+
Gastropoda	13					
Echinodermata		0.02	29		0.01	13
Total		0.01	1			-

monly observed with density of 29 inds: kg^{-1}. The remaining animal groups represented separate individuals at inappreciable biomass. The total biomass of epibiosis were 0.19 g kg^{-1} (96 inds: kg^{-1}). Qualitative composition of epiphytes did not vary much with depth increase. At 5 m depth, dominate echinoderms (Ophiuroidea) were observed with a biomass and density at 0.11 g(kg^{-1} and 56 inds: kg^{-1}, respectively. Gastropod density (23 inds: kg^{-1}) increa- sed which were represented by species of the genera *Mitrella*, *Triphora* and *Turbo*, however, crustaceans be- came much less. The total biomass of *Sargassum* epibiosis were 0.16 g kg^{-1} (105 inds: kg^{-1}).

Table 4. Biomass (B, g· kg^{-1}) and abundance (A, inds. kg^{-1}) of epiphytes on *Halimeda* spp. in the sublittoral of Aldabra Island.

Taxon	Depth (m)					
	12 m		20 m			
Rhodophyta						
Fosliella farinosa		+		-		
Griffithsia spp.	+		-			
Peyssonnelia dubyi		+		-		
	+		-			
Spongia		1.10		-		
Coelenterata	-		-			
Polychaeta		2.94		-		
Isopoda	2.66		-			
Amphipoda		0.15		-		0.41
Decapoda	-					
Pantopoda		0.12	35			+
Gastropoda	+					
Bryozoa			+ 3		0.09	21
Echinodermata		0.32	237		0.18	166
Tunicata		2.00	30		0.62	21

Epiphytic Community of *Halimeda* spp.

Epiphytes on *Halimeda* spp. were investigated in the sublittoral zone of Aldabra Island. Calcified green alga, *Halimeda* spp. was observed within all investigated depth ranges, however, its epiphytes were detected only at depths greater than 12 m. A total of 18 species of epiphytic algae were collected (Cyanophyta - 1, Chloro -phyta - 2, Phaeophyta - 1, Rhodophyta - 14 species) (Table 1). Red algae, *Griffithsia* spp, *Fosliella farinosa* and *Peyssonnelia dubyi*, covering 10-15 % of surfaces of a macrophyte-substratum represented the epiphytes of *Halimeda* spp. thickets (Table 4). Despite of this coverage, the epiphytes did not result in any significant biomass, with an exception of *Peyssonnelia dubyi* at 12 m depth (1.1 g kg^{-1}); the fauna part of an epibiosis were rather fully represented by main systematic groups. At 12 m depth, sponges (2.9 g kg^{-1}) and decapods (2.0 g kg^{-1}) were observed; the part of remaining animal groups did not make the basis of the biomass. The total biomass of the epibiosis was 7.4 g kg^{-1} (365 inds. kg^{-1}). In this community, quantitatively dominant species were amphi- pods. At 20 m depth, the role of the motile forms was reduced, its total density was lowered to 241 inds.· kg^{-1}. Sponges and crusted bryozoans with biomass 2.7 and 2.4 g kg^{-1}, respectively, were the predominant species among the attached forms. Tunicate biomass (1.6 g kg^{-1}) did not increase anymore. Moreover, quantitative characteristics of the remaining animal groups varied insignificantly. The total biomass of epibiosis was 8.5 g kg^{-1}, and density of a settlement of the motile forms was 241 inds: kg^{-1}).

Epiphytic Effects on Photosynthetic Rates

From the above results, total 84 species of algae were identified as epibiotic macrophytes (Table 1). The maximal specific richness (59 species) was red algae. Despite of specific richness, only few animal groups and algal species of the community showed any considerable bio-

mass. However, some epiphytic red algae of the genera *Griffithsia* and *Fosliella*, albeit with inappreciable mass, showed massive coverings (up to 30 - 80 %) on *Thalassodendron* leaves. It influenced development and production of the substrates. The results revealed that even 10 % covering of a leaf by epiphytes tended to decrease 1.72 times a level of light saturation of photosynthesis (Fig. 4). The change in primary production of covered and uncovered leaves with epiphytes of Thalassodendron showed a reliable difference ($t = 6.718$ at $P < 0.001$). At the maximal degree of epiphytic covering of *Thalassodendron* leaves (up to 80 %), it was expected to increase of this index several times. Thus, at an estimation of production indices of macrophytes, it is necessary to consider the intensity of various epiphytic communities.

4. Conclusion

Comparative analyses of epiphytes indicated several tendencies in their distribution. The dependence of distribution and biomass of various epiphytic groups with growth depth of macrophytic was characteristic for *Thalassodendron ciliatum* community. The higher number of the motile animals was typical for shallow depths, whereas the role of the attached forms was inappreciable. The similar characteristic was also observed for *Halimeda* thickets. On shallow sites, where a great amount of light can penetrate, conditions existed favoring the mass development of a microepiphyton, particularly the diatoms. This created favorable conditions for phytophages development. With increasing depths, the biomas of detritophages (primarily the bryozoans and sponges) and encrusting organisms also increased. The biomass of epiphytes decreased in accordance with depth increases; therefore, the role of epiphytic algae became no longer significant. Changes of qualitative composition expressed in lowering the role of red algae and its substitution by green algae at greater depths.

Other factors hold for the *Sargassum* thickets. Therefore, the depth increases essentially did not influence the total biomass of an epibiosis, however, increasing trends were observed in the density of the motile forms settlement. The attached organisms (hydroids) were observed only in qualitative samples. *Thalassoden-dron* and *Halimeda*, unlike *Sargassum*, have densely branched thalli, which enlarges potential area for detritus settling. The depth increases conjugated with lowering wave action intensity and created favorable conditions for detritus accumulation, which promoted mass development of detritophages.

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