

Plant Part Age and Size Affect Sessile Macrobenthic Assemblages Associated with a Foliose Red Alga *Phycodrys rubens* in the White Sea

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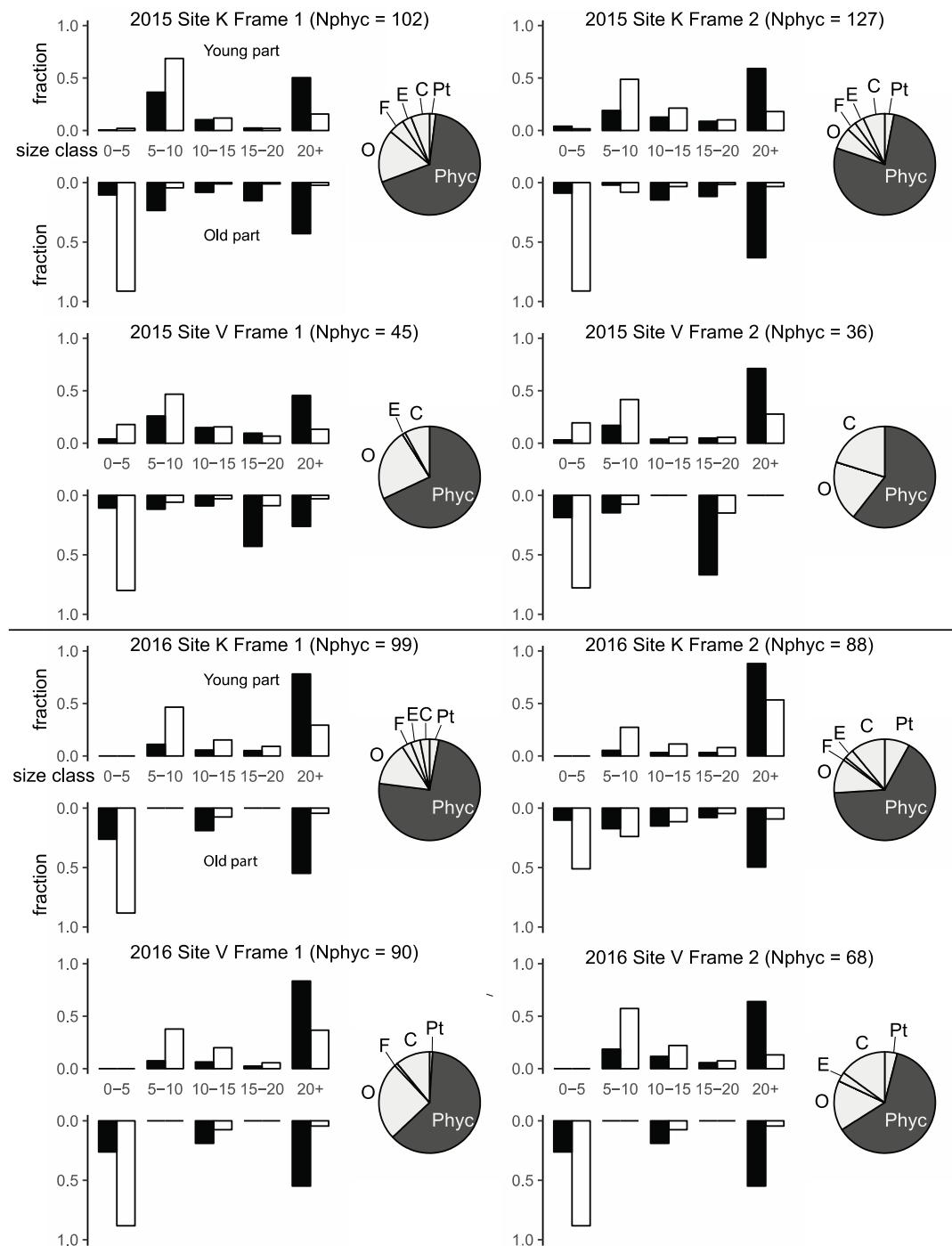


Figure S1. Size structure of *Phycodrys rubens* and its proportion compared to other red macroalgal species on September 24, 2015 and October 1, 2016 by site and frame. Barcharts: distribution of *P. rubens* individuals by approximated blade surface area (white bars) and their contributions to total *P. rubens* surface area (black bars). Young plant parts plotted upwards, old plant parts plotted downwards, size classes denote approximated blade surface area of the corresponding part in cm^2 . Piecharts: relative wet weights of red macroalgae by species. Phyc – *P. rubens*; O – *Odonthalia dentata*; F – *Fimbrifolium dichotomum*; E – *Euthora cristata*; C – *Coccylus truncatus*; Pt – *Ptilota gunneri*. N_{phyc} – number of *P. rubens* individuals in a 0.25 m^2 frame.

Table S1. Average number (N) and wet weight (W) in grams of foliouse red algae per 1 m² of the bottom in September-October by species and year ($n = 4$ frames, sites pooled).

Year		<i>Phycodrys Rubens</i>	<i>Odonthalia Dentata</i>	<i>Fimbrifolium Dichotomum</i>	<i>Coccotylus Truncatus</i>	<i>Euthora Cristata</i>	<i>Ptilota Gunneri</i>
2015	N	310 ± 88	56 ± 7	21 ± 10	88 ± 15	25 ± 10	18 ± 9
	W	130.3 ± 29.3	27.3 ± 3.0	4.6 ± 2.4	18.2 ± 4.7	3.4 ± 1.8	2.5 ± 1.6
2016	N	342 ± 24	107 ± 17	8 ± 4	90 ± 25	42 ± 11	48 ± 15
	W	357.6 ± 64.0	90.9 ± 27.6	6.6 ± 4.1	52.4 ± 15.1	9.8 ± 3.6	22.7 ± 11.4

Table S2. Contribution of 20 largest *Phycodrys rubens* plants to approximated total area in a frame (ATA) and total wet weight (TWW) in September-October by year, site and frame.

Sampling Date	September 24, 2015				October 1, 2016			
	Site	K	K	V	V	K	K	V
Frame	1	2	1	2	1	2	1	2
ATA, cm ²	1528	2795	716	814	3911	4397	4134	1873
ATA of 20 largest, cm ²	884	1793	448	404	2859	2789	2936	1341
%ATA of 20 largest	58	64	63	50	73	63	71	72
TWW, g	30	54	24	23	96	112	104	42
TWW of 20 largest, g	24	37	23	22	80	82	86	38
%TWW of 20 largest	81	68	97	96	83	73	82	91

Table S3. Approximated surface area (cm²) of *Phycodrys rubens* per 1 m² in September-October by plant part age, site and year, frames pooled.

Sampling Date	Site	Young Parts Area	Old Parts Area	Total Area
September 24, 2015	K	15558	1733	17291
September 24, 2015	V	5221	898	6118
October 1, 2016	K	27102	6131	33233
October 1, 2016	V	19673	4357	24030

Table S4. Mann-Whitney U-tests comparing total cover of the epibiosis on *Phycodrys rubens* in September 2015 between the two replicate frames by site and plant part age.

Site	Plant Part Age	Subsample	U	Z	p	N ₁	N ₂
K	young	random plants only	95	-0.705	0.481	15	15
V	young	random plants only	102	-0.415	0.678	15	15
K	old	random plants only	12	-1.240	0.215	4	11
V	old	random plants only	15	0.091	0.927	5	6
K	young	random + large plants	187	-0.338	0.735	20	20
V	young	random + large plants	170	-0.798	0.425	20	20
K	old	random + large plants	38	-1.897	0.058	9	16
V	old	random + large plants	55	0.035	0.972	10	11

Table S5. Kolmogorov–Smirnov (KS) and Mann–Whitney (MW) U-tests comparing total plant surface areas and the proportion of young blades' surface of *Phycodrys rubens* between the pairs of replicate frames in September 2015 by sampling site. Sample sizes for randomly sampled plants $N_1 = N_2 = 15$, for random + large plants $N_1 = N_2 = 20$; see text for details.

Variable	Site	Subsample	KS-test		MW U-test		
			D	p	U	Z	p
Total plant surface area	K	random plants only	0.4	0.136	73	-1.618	0.106
Total plant surface area	V	random plants only	0.2	0.89	102.5	-0.394	0.693
Proportion of young blades' surface	K	random plants only	0.47	0.051	70	-1.862	0.063
Proportion of young blades' surface	V	random plants only	0.2	0.89	103	-0.432	0.666
Total plant surface area	K	random + large plants	0.3	0.275	153	-1.258	0.208
Total plant surface area	V	random + large plants	0.15	0.965	182.5	-0.46	0.646
Proportion of young blades' surface	K	random + large plants	0.35	0.135	149	-1.403	0.161
Proportion of young blades' surface	V	random + large plants	0.15	0.965	184	-0.444	0.657

Table S6. Effects of plant part age (fixed, young or old), month (fixed, July or September), and location (fixed, sites K or V) on total cover of *Phycodrys rubens* epibiosis in 2015: beta-regression, mean (logit link) and variance (log link) modeled, replicate 0.25 m² frames included as a fixed effect nested in Site × Month with two levels per site (see Methods for details). Auxiliary non-randomly sampled (in September only) five largest plants per frame not included. Significant terms in a mean model highlighted in bold.

Model	Source of Variation	Estimate	SE	t-value	p
Plants having both old and young parts (with Plant ID as a random blocking factor nested in Site × Month × Frame; n = 51 plants)	Intercept	-5.4548	0.5373	-10.152	<0.001
	Site [level 'K']	-0.1024	0.2202	-0.465	0.643
	Age [level 'Old']	3.4217	0.9030	3.789	<0.001
	Month [level 'September']	3.1399	0.5164	6.080	<0.001
	Frame (Site × Month) [level 'Jul K-2']	-1.5023	0.5688	-2.641	0.010
	Frame (Site × Month) [level 'Jul K-3']	-1.4284	0.5972	-2.392	0.019
	Mean (Mu)	Frame (Site × Month) [level 'Jul V-1']	1.1732	0.6625	1.771
		Frame (Site × Month) [level 'Jul V-2']	0.6429	0.6624	0.971
		Frame (Site × Month) [level 'Jul V-3']	0.1390	0.8822	0.158
		Frame (Site × Month) [level 'Sep K-1']	-0.2771	0.2257	-1.228
		Frame (Site × Month) [level 'SepV-1']	-0.1017	0.2088	-0.487
		Site × Age	1.9685	0.9996	1.969
		Age × Month	-2.1639	0.9617	-2.250
		Site × Age × Month	-0.6280	1.1178	-0.562
		Intercept	-2.4697	0.4795	-5.150
Plants having only young parts (n = 39 plants)	Site [level 'K']	0.3145	0.3915	0.803	0.424
	Age [level 'Old']	1.9101	0.9761	1.957	0.054
	Month [level 'September']	0.3541	0.3940	0.899	0.372
	Frame (Site × Month) [level 'Jul K-2']	-1.7496	0.4308	-4.061	<0.001
	Frame (Site × Month) [level 'Jul K-3']	-1.9890	0.6384	-3.115	0.003
	Mean (Mu)	Frame (Site × Month) [level 'Jul V-1']	0.4871	0.5544	0.879
		Frame (Site × Month) [level 'Jul V-2']	0.1603	0.5965	0.269
		Frame (Site × Month) [level 'Jul V-3']	-1.0625	1.4861	-0.715
		Frame (Site × Month) [level 'Sep K-1']	-0.6590	0.3919	-1.681
		Frame (Site × Month) [level 'Sep V-1']	-0.1210	0.3742	-0.323
		Site × Age	1.2289	1.1222	1.095
		Age × Month	0.0453	1.0499	0.043
		Site × Age × Month	-0.1733	1.2399	-0.140
		Intercept	-3.1035	0.2552	-12.162
		Site [level 'K']	-0.4005	0.1768	-2.265
		Month [level 'September']	0.7759	0.2178	3.563
Plants having only young parts (n = 39 plants)	Frame (Site × Month) [level 'July K-3']	1.0807	7.4705	0.145	0.886
	Frame (Site × Month) [level 'July V-3']	-1.3759	0.3420	-4.023	<0.001
	Frame (Site × Month) [level 'Sep K-1']	0.1191	0.1795	0.664	0.513
	Frame (Site × Month) [level 'Sep V-1']	0.4981	0.3046	1.635	0.115
	Variance (Sigma)	Intercept	-2.3113	0.6957	-3.322
		Site [level 'K']	-0.7719	0.4575	-1.687
		Month [level 'September']	0.2564	0.6439	0.398
		Frame (Site × Month) [level 'Jul K-3']	3.3916	6.4896	0.523
		Frame (Site × Month) [level 'Jul V-3']	-1.0385	0.8693	-1.195
					0.243

Frame (Site × Month) [level 'Sep K-1']	0.7805	0.4442	1.757	0.091
Frame (Site × Month) [level 'Sep V-1']	1.2077	0.3947	3.060	0.005

Table S7. Effects of plant part age (young or old), month (July or September), and location (sites K or V) on multivariate community structure of epibiosis on *Phycodrys rubens*: type III sum of squares PERMANOVA for 9999 permutations on fourth root transformed covers of sessile epibionts, Bray-Curtis similarity, replicate 0.25 m² frames included as a fixed effect nested in Site × Month with two levels per site (see Methods for details). Auxiliary non-randomly sampled (in September only) five largest plants per frame not included. Smaller df Significant terms highlighted in bold. [f] – fixed effect, [r] – random effect.

Source of Variation		df	SS	MS	pseudo-F	p	Unique Permutations
Plants having both old and young parts (<i>n</i> = 51 plants)	Site [f]	1	24681	24681	16.86	0.0001	9947
	Month [f]	1	28677	28677	19.60	0.0001	9953
	Age[f]	1	24172	24172	25.84	0.0001	9950
	S × M [f]	1	6419	6419	4.39	0.0005	9940
	S × A [f]	1	2921	2921	3.12	0.0068	9952
	M × A [f]	1	16015	16015	17.12	0.0001	9949
	S × M × A [f]	1	1416	1416	1.51	0.1794	9947
	Frame (S × M) [f]	6	9394	1566	1.07	0.3642	9891
	Plant ID (F (S × M)) [r]	41	59995	1463	1.56	0.0003	9807
	Error	47	43960	935			
Plants having only young parts (<i>n</i> = 39 plants)	Site [f]	1	2804	2804	2.78	0.0219	9957
	Month [f]	1	10579	10579	10.48	0.0001	9947
	Frame (S × M)	3	8047	2682	2.66	0.0013	9930
	S × M [f]	1	4460	4460	4.42	0.0011	9950
	Error	32	32291	1009			

Table S8. Effects of plant part size (surface Area of the corresponding part, cm²) and location (Sites K or V) on total cover of epibiosis on young and old parts of *Phycodrys rubens* in September 2015: beta-regression, mean (logit link) and variance (log link) modeled, replicate 0.25 m² frames included as a fixed effect nested in Site with two levels per site (see Methods for details). Significant terms in a mean model highlighted in bold.

Age	Model	Source of Variation	Estimate	SE	t-value	p
Young parts (n = 80)	Mean (Mu)	Intercept	-2.2541	0.0997	-22.61	<0.001
		Site [level 'K']	-0.3308	0.1340	-2.47	0.016
		Area	-0.0029	0.0012	-2.37	0.020
		Frame (Site) [level 'K-1']	0.1154	0.1270	0.91	0.366
		Frame (Site) [level 'V-2']	0.0991	0.1513	0.66	0.545
	Variance (Sigma)	Site × Area	0.0004	0.0015	-0.24	0.811
		Intercept	-1.9211	0.2008	-9.57	<0.001
		Site [level 'K']	-0.2136	0.2697	-0.79	0.431
		Area	-0.0136	0.0040	-3.36	0.001
		Frame (Site) [level 'K-1']	0.1387	0.2469	0.56	0.576
Old parts (n = 46)	Mean (Mu)	Frame (Site) [level 'V-2']	0.8329	0.2478	3.36	0.001
		Site × Area	0.0100	0.0045	2.20	0.031
		Intercept	-1.6669	0.3269	-5.10	<0.001
		Site [level 'K']	0.4184	0.3469	1.21	0.234
		Area	0.0725	0.0233	3.11	0.003
	Variance (Sigma)	Frame (Site) [level 'K-1']	1.8232	0.2531	7.20	<0.001
		Frame (Site) [level 'V-2']	0.0874	0.3569	0.25	0.808
		Site × Area	-0.1001	0.0238	-4.20	<0.001
		Intercept	-0.6596	0.3505	-1.88	0.067
		Site [level 'K']	-1.1600	0.4515	-2.57	0.014
	Variance (Sigma)	Area	0.0049	0.0254	0.19	0.848
		Frame (Site) [level 'K-1']	3.2681	0.3490	9.36	<0.001
		Frame (Site) [level 'V-2']	0.2276	0.3898	0.58	0.563
		Site × Area	-0.0527	0.0272	-1.93	0.060

Table S9. Effects of plant part size (surface Area of the corresponding part, cm²) and location (Sites K or V) on the number of species and diversity (H') on young and old plant parts of *Phycodrys rubens* in September 2015: type III sum of squares ANCOVAs, replicate 0.25 m² frames included as a fixed effect nested in Site with two levels per site (see Methods for details). Arrows show the sign of the relationship where covariate effect or interaction is significant. Significant terms highlighted in bold.

Age	Parameter	Source of Variation	df	Sum of Squares	F-value	p
Young parts	H' (based on % cover)	Site	1	0.0005	0.005	0.943
		Area	1	1.7016	18.382	<0.001 ↑
		Frame (Site)	2	0.1466	0.792	0.457
		Site × Area	1	1.0697	11.555	0.001 K↑ V↑
		Error	74	6.8503		
	Number of species	Site	1	19.9	3.013	0.087
		Area	1	647.3	98.126	<0.001 ↑
		Frame (Site)	2	3.4	0.256	0.775
		Site × Area	1	71.2	10.787	0.002 K↑ V↑
		Error	74	488.1		
Old parts	H' (based on % cover)	Site	1	0.3757	1.716	0.198
		Area	1	0.2804	1.281	0.265
		Frame (Site)	2	1.9934	4.552	0.017
		Site × Area	1	0.7530	3.439	0.071
		Error	40	8.7586		
	Number of species	Site	1	33.7	2.898	0.096
		Area	1	526.8	45.284	<0.001 ↑
		Frame (Site)	2	59.4	2.554	0.090
		Site × Area	1	4.0	0.343	0.561
		Error	40	465.3		

Table S10. Effects of plant part size (surface Area of the corresponding part, cm²) and location (Sites K or V) on multivariate community structure of epibiosis on young and old plant parts of *Phycodrys rubens* in September 2015: type III sum of squares PERMANOVA for 9999 permutations on fourth root transformed covers of sessile epibionts, Bray-Curtis similarity, replicate 0.25 m² frames included as a fixed effect nested in Site with two levels per site (see Methods for details). Significant terms highlighted in bold.

Age	Source of Variation	df	SS	MS	pseudo-F	p	Unique Permutations
Young parts	Area	1	5107	5107	6.28	0.0001	9943
	Site	1	13817	13817	16.99	0.0001	9938
	Frame (Site)	2	2842	1421	1.75	0.0362	9937
	Site × Area	1	1563	1563	1.92	0.0650	9917
	Error	74	60185	813			
Old parts	Area	1	4954	4954	4.54	0.0001	9938
	Site	1	9736	9736	8.92	0.0001	9940
	Frame (Site)	2	6122	3061	2.80	0.0002	9908
	Site × Area	1	2294	2294	2.10	0.0296	9946
	Error	40	43660	1092			

Table S11. Effects of plant part size (surface Area of the corresponding part, cm²) and location (Sites K or V) and on mean individual size (approximated area occupied, mm²) of 5 top abundant species on young and old plant parts of *Phycodrys rubens* in September 2015: type III sum of squares ANCOVAs, frames pooled. Arrows show the sign of the relationship where covariate or interaction effect is significant. Significant terms highlighted in bold.

Age	Species	Source of Variation	df	Sum of Squares	F-value	p
Young parts	<i>Cribrilina annulata</i>	Site	1	9.86×10^{-6}	0.3461	0.558
		Area	1	1.00×10^{-6}	0.0351	0.852
		Site × Area	1	2.33×10^{-5}	0.8181	0.369
		Error	76	0.0020		
	<i>Electra pilosa</i>	Site	1	0.0014	12.8543	<0.001
		Area	1	1.54×10^{-6}	0.0141	0.906
		Site × Area	1	7.80×10^{-7}	0.0072	0.933
		Error	76	0.0069		
	<i>Celleporella hyalina</i>	Site	1	0.0003	4.0997	0.047
		Area	1	0.0004	5.4123	0.023
		Site × Area	1	3.57×10^{-5}	0.5387	0.466
		Error	76	0.0043		
	<i>Circeis armoricana</i>	Site	1	3.74×10^{-7}	0.5828	0.448
		Area	1	1.19×10^{-6}	1.8561	0.177
		Site × Area	1	3.59×10^{-6}	5.6021	0.021
		Error	76	4.88×10^{-5}		K↓ V↑
	Porifera	Site	1	0.0151	1.3162	0.257
		Area	1	0.0223	1.9498	0.169
		Site × Area	1	0.0076	0.6614	0.420
		Error	76	0.5378		
	<i>Cribrilina annulata</i>	Site	1	$3.05 \cdot 10^{-5}$	0.6365	0.432
		Area	1	2.76×10^{-5}	0.5759	0.455
		Site × Area	1	3.91×10^{-5}	0.8141	0.375
		Error	42	0.0013		
	<i>Electra pilosa</i>	Site	1	0.0013	2.2583	0.143
		Area	1	1.01×10^{-5}	0.0017	0.967
		Site × Area	1	1.85×10^{-5}	0.0032	0.955
		Error	42	0.0181		
	Old parts	Juvenile mytilids	Site	1	0.0024	1.8196
			Area	1	0.0002	0.1323
			Site × Area	1	0.0007	0.4881
			Error	42	0.0228	0.494
		<i>Circeis armoricana</i>	Site	3.80×10^{-9}	0.0023	0.962
			Area	5.72×10^{-6}	3.4214	0.073
			Site × Area	1	8.13×10^{-6}	4.8581
			Error	42	$5.52 \cdot 10^{-5}$	K↑ V↓
		Porifera	Site	1	0.5229	1.0624
			Area	1	2.7079	5.5020
			Site × Area	1	2.8871	5.8661
			Error	42	20.179	K- V↑

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